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In Memoriam

ANGELO HEILPRIN.

Memorial Address delivered before the Franklin Institute September 18th, 1907

BY LOUIS EDWARD LEVY.

Through the death of Professor Angelo Heilprin, on the 17th of July last, the Franklin Institute lost not only one of its most distinguished members, but also one of the most welcome of its frequent lecturers and, in common with the world of science generally, a recognized leader in the search for knowledge. While Professor Heilprin's researches dealt primarily with the natural sciences, their results led, as does every enlargement of our

knowledge, to a better understanding of our true relation to surrounding nature and a clearer comprehension of its workings. Applied to our daily life, this deeper insight into the facts of nature brings us to a more normal attitude towards its varying manifestations and enables us to deal more effectively with its various forces.

No better illustration of these conditions need be cited than that presented by the paramount influence of Professor Heilprin's work in determining the location of the inter-oceanic canal across the Isthmus of Panama, instead of along the more facile and in certain other respects more desirable route through Nicaragua. The respective merits and difficulties of these two routes had been debated for years by experienced engineers, by learned geologists, by journalists and by statesmen, and when the choice was finally to be made by act of Congress, the Senate wavered in its decision, many of its members remaining undecided in their opinion. At this juncture Heilprin, then investigating the volcanic conditions attending the catastrophe at Mont Pelée, announced his conclusions through the Philadelphia *Press*. In a telegram to that journal he said:—"My studies of what has happened here throw added light on the Isthmian Canal question. The catastrophism here is without parallel. Its relation with conditions at St. Vincent establishes the certainty of a long volcanic circuit, whose existence should dispose of Nicaragua as a canal route." His telegram closed with the statement that "The facts all prove the broad reach of volcanic force, and that reliance for the protection of a canal running through a volcanic country like Nicaragua, on the localization of volcanic force, its assumed dormancy, or the resistibility of the canal to its destructive action, is absurd."

The effect of this announcement was decisive. It brought conviction to the minds of Senators who had remained unconvinced by the arguments presented by Senator Hanna and other leading advocates of the Panama route, and left the Nicaragua project but a small minority of supporters, headed by Senator Morgan of Alabama. But it was not only in Congress that Heilprin's authoritative announcement brought conclusion to this much vexed question. His investigations influenced public opinion on the subject throughout the country and settled it permanently in favor of the Panama route.

"It is characteristic of Professor Heilprin," says *The Press* in its recent chronicle of the scientist's death, "that in this, as in other matters, he profited not a penny, though in the final transfer of the Panama interests to the United States, many men obtained millions for services of a trifling character compared with those which he had rendered." Absolute disinterestedness was not, however, the only shining quality of Heilprin's character. He was as blithe and genial as he was earnest and resolute, as modest and unassuming as he was fearless and determined. In the pursuit of his investigations, whether in the fire-scathed ruins of St. Pierre or amid the icy wastes of the frozen north, or surveying the plateau of Mexico from the snow-capped summit of Orizaba, Heilprin's purpose was simply that of the student scientist, whose function is first of all to bring to light the truth. It was for this that he repeatedly climbed Pelée and with death and destruction threatening close about him made a deliberate and careful study of its fiery outpour while the volcano raged in all its fury and was going, as he himself expressed it, "in full blast."

In a volume entitled "Mont Pelée and the Tragedy of Martinique," the story of his findings is simply but graphically told.

As he had pressed into the stormy wastes of the Arctic wilderness in search of Peary ten years before, he in this wilderness of fire pressed farther and farther toward the summit of the volcano, until he stood high among the clouds, amid lightning flashes and rolling thunder, and under a torrent of rain, with the outpour from the crater blackening the air about him and his few companions, and, in his own words, "as an unseen neighbor of one of the mightiest destroying engines of the globe." On the first ascent the rain storm forced him to retire, but on the following day, with George Kennan, Jaccaci and Varian, he ascended again and pushed through a scorching heat to within four feet of the fiery abyss, standing on a foothold of the stability of which he knew nothing and looking directly down into the crater's mouth. Kennan, in his report of the ascent, remarks: "I must pay the highest possible tribute to Heilprin. He is modest and brave, a superb mountaineer and the nerviest and pluckiest man I ever knew. The ascent was the most terrifying experience of my life." In his own narrative Heilprin says: "I felt that finally I had stood over Nature's great laboratory and been permitted to study some of its workings. Many years be-

fore, on Vesuvius, I had gazed into the crater funnel and watched the molten magma of the earth rise and fall, but the scene was one which could not compare with this, grand and inspiring though it was."

This was on the first of June, 1902. On the 30th of the following August, Heilprin made another ascent of the mountain with a view to determining the nature of the cone that was then apparently developing in the midst of the volcano's crater. He was accompanied by Julian Cochrane and by a number of native carriers. As they approached the summit the party was halted by a fusilade of exploding bombs horizontally shot out from the roaring column of steam and incandescent scoria that was being intermittently belched out from the seething crater, miles high into the air. Leaving his companions, Heilprin pushed upward to a point just below the crater's rim, crouching on the palpitating ground for all possible safety, and there made his observations amid the crash and roar of the terrific phenomena which he was studying. That night, after his return to the base of the mountain, the tragedy of St. Pierre was repeated all about him. A scorching blast, like that of the fatal 8th of May, was shot downward from the fiery summit of Pelée, sweeping through the nearby villages of Morne Rouge and Ajoupa Bouillon, carrying destruction to everything in its path and death to fully fifteen hundred of their inhabitants. The scientist, housed in a depression nearer the mountain's base, was fortunately beneath the line of the fiery discharge and so escaped with his life.

The phenomena of vulcanism, the tremendous outrush from mountain tops of fire and molten rock, the bursting forth of vast columns of flaming gases, of steam and of smoking scoriæ, have been a source of terror to the inhabitants of surrounding districts and a focus of allurement for philosophers and scientists from the dawn of history to the present day. It is remarkable that the two principal volcanos of Europe, Ætna and Vesuvius, have become historically signalized through two of the great scientists of classic antiquity having perished while studying their eruption. Empedocles, the half-deified Greek philosopher of Sicily, lost his life while investigating an eruption of Mt. Ætna in 430 B. C., his fate betokened only by the remnants of his brass sandals, and five centuries later, in the year 79, the great Roman naturalist, Pliny, hastened from a place of safety to study

the eruption of Vesuvius, and was suffocated by the sulphurous gases from the mountain while the neighboring cities of Pompeii and Herculaneum were being buried by its fiery outpour. And, now, in our own time, over eighteen centuries after Pliny's memorable dying day, another volcanic eruption, the most woefully tragic since that time, burst through the long-slumbering craters of the Carribean Islands and with the record of that catastrophe and the story of the destruction of St. Pierre, the name of another devoted scientist, Angelo Heilprin, will go into history. But this time, fortunately for the advancement of science, as well as for the explorer himself, the life of the intrepid student was not sacrificed in the quest, and the sum of human knowledge regarding the nature of volcanic action—a quantity remarkably small in comparison with the gains of science generally—has been augmented by the contributions of a keen and competent observer, made, not from some neighboring point of vantage, but on the very edge of the fire-belching chasm itself.

Those memorable explorations, now become historic, not only because of their singularity but also because of the far reaching importance of their results, were followed by yet other expeditions to the same locality, in the course of which Heilprin made a close study of the unique phenomenon which reached its full development in the later stages of the volcano's activity. This was the remarkable Tower of Pelée, so called by Heilprin and first observed by him on his ascent on August 30th and afterwards determined by him to be a mass of solidified magma, which, according to his latest investigations, was simply the mass of cooled material remaining as a core in the funnel of the volcano after its eruption in 1851. This core, pushed up through the crater by the gathering pressure of the volcanic forces from below, was gradually projected vertically outward until it towered more than one thousand feet above the crater, finally toppling in successive masses over the mountain side.

No similar phenomenon has ever before been recorded in history. It was this core of solid magma, choking the throat of the volcano, that prevented the eruption at the beginning from following a normal course in the vertical direction, and by causing the pent-up and super-heated gases to burst forth in a horizontal discharge, which unhappily was in the direction of St. Pierre, brought about the destruction of that city and the almost instant

death of all its 30,000 inhabitants. The downward blast of August 30, which so fatally swept through the neighboring villages, was due to the same cause. Heilprin's investigations of the phenomenon presented by this obstruction have thrown new light on the history of the Vesuvian eruption of the year 79, which in many of its aspects, as reported by the younger Pliny, and as further revealed by the excavations at Pompeii, had hitherto remained inexplicable. In the second of his books on the Martinique disaster, published in 1905 under the title of "The Tower of Pelée," Professor Heilprin has treated this subject, both as scientist and as historian, with lucid understanding and with a graphic hand.

Heilprin's investigations of volcanic phenomena were but part of a series of similar explorations in other fields of scientific research. These began at a very early stage of his career, in fact, during the intervals in his educational courses. His earliest predelictions had been in the direction of natural history, and though he eventually developed considerable mastery as a painter and had also a marked talent as a musician, his controlling bent was to the study of science for the sake of knowledge alone, and for that he evinced from the beginning a readiness to adventure whatever it demanded or wherever it called.

Angelo Heilprin was born in Hungary, March 31st, 1853. His talents were inherited, his grandfather, Phineas Mendel Heilprin (1801-63), having been a recognized authority in Hebrew literature and a close student of the Kantian philosophy among the writers and scholars of the earlier half of the 19th century, and the Professor's father, Michael Heilprin (1823-88), having in his turn achieved high rank among the erudite scholars of his generation as a Biblical exegetist and literary critic. The grandfather, fleeing from Russian tyranny in his native Poland, had been compelled to take refuge in Hungary; the father had become associated with Kossuth during the struggle for freedom in the revolution of 1848 and had been compelled in his turn to flee before the Austrian conqueror. In common with other leaders of that rising, Michael Heilprin made his way to America, reaching this country with his family in 1856 and settling in Philadelphia. Two years later the family moved to Brooklyn, and there in 1860 Angelo Heilprin's education was begun in a public school. This training, however, but supplemented the

educational influences of his home. There his innate impulse towards the study of natural science was emphasized by the teachings of his learned father and under that influence young Heilprin's receptive mind rapidly compassed a wide domain of knowledge. Even before his 20th year he had become a capable associate, along with his elder brother, Louis Heilprin, in the work of their father as revising editor of the American Cyclopædia, he himself adding a number of original articles, notably the biographical sketch of John Tyndall. In his 24th year, in 1876, he went to London to take up the study of the natural sciences at the Royal School of Mines, now known as the Normal School of Science. There he learned his way in biology from Huxley, in palæontology from Etheridge and in geology from Judd, his efforts gaining for him the award of the Forbes medal for proficiency in the two former of these branches. Thereafter he studied in Paris; later journeyed on foot through the Swiss Alps and learned what he could of their glaciers, and then spent some eight months at Geneva, attending the lectures of Professor Carl Vogt and studying at the Natural History Museum in that city. From there he made his way through Italy, delving everywhere to add to his store of knowledge, and after a prolonged journey turned back through the Tyrolean Alps to Vienna and thence to Hungary, all on the same quest. After a time spent in Russian Poland, completing a three years' stay in Europe, he returned to America in June, 1879, having developed in his own original manner his gift of critical and accurate observation.

Soon after his return began his connection with the Academy of Natural Sciences of this city and his permanent residence here. In January, 1880, he was awarded the Jessup Fellowship of the Academy and by the end of the year his original contributions to its publications led to his election as Professor of Invertebrate Palæontology by that institution. Three years later, in October, 1883, his abilities were further recognized by the Academy through his election as one of the four members of its Board of Curators, and soon thereafter followed his appointment by the Council of the Academy as Curator in Charge.

In this position, which he held until his resignation in 1892, Prof. Heilprin was soon confronted with the difficulties incident to a lack of adequate room for the proper arrangement and display of the growing collections of the Academy, many of which

had of necessity to be stored out of sight. He took a leading part in a movement for the erection of an annex building to house the museum, and when eventually the Academy appealed to the State for financial aid to this end, Heilprin's eloquent address to the Legislature and his personal appeals to many of its individual members, were largely instrumental in obtaining the two appropriations of $50,000 each which were voted to the Academy in 1889 and 1891.

Soon after taking up his residence in this city Heilprin was impelled, through his studies at the Academy, to undertake the task of making a general and systematic review and analysis of the tertiary geology of each of the several States of the Atlantic and Gulf borders where that formation had been recognized. The results of his research were embodied in a series of notable papers, printed in the *Quarterly Journal* of the Academy, and in 1884 these papers were collected and with various later additions were published in book form under the title of "Contributions to the Tertiary Geology and Palæontology of the United States." The *American Journal of Science* characterized the work as "of great service to American geology."

There was next published, in 1885, "Town Geology: The Lesson of the Philadelphia Rocks. Studies of Nature Along the Highways and Among the Byways of a Metropolitan Town." It was a printed issue of the author's field lectures upon the geology of Philadelphia. Said the *Popular Science Monthly* in reference to it: "The present volume is an admirable exemplification of the true method of geological study. The author takes up features with which all Philadelphians are familiar and in which they may, therefore, be assumed to have a certain degree of interest, and connects them in a very simple and instructive way with the great body of geological truths in which these facts find their explanation. * * 'White Marble Steps and Window-Facings,' 'Brownstone Fronts and Jersey Mud,' 'Philadelphia Brick and Cobble-Stone,' are the familiar texts used by the author to interpret the wonderful workings of Nature in the immeasurable past, which, through long chains of causes and effects, have given rise to the present order of things."

In that year—1885—the Wagner Free Institute of Science, then reorganized under the will and bequest of its beneficent founder, Dr. William Wagner, called Professor Heilprin to con-

duct its courses in geology. By a special arrangement with the Academy he was enabled to undertake this work and continued it until 1890. In 1888 he accepted also the duties of Curator of the institution and thoroughly rearranged its museum.

It was soon after he became connected with the Wagner Institute and under the joint auspices of that organization and the Academy of Natural Sciences, that Heilprin began that series of scientific explorations which have so greatly distinguished his career, and which have added so largely to our store of accurate knowledge in various of the natural sciences. In 1886 he organized and led an expedition to the wilds of Florida, of which but little accurate information was then accessible, and that little yet awaited confirmation. The fauna of the seashore and of the interior lake region had not up to that time been closely investigated and proved a fertile source of new scientific data.

An important result of this exploration was the complete disproof of the previously accepted theory that the peninsula was of coraline formation, Heilprin's investigations bringing to light the fact that notwithstanding the indications furnished by the coral fringe along the coast, the body of the peninsula presents a sedimentary calcareous structure. The report of this expedition, with an introduction by Dr. Joseph Leidy, President of the Academy, was published in 1887 as the first volume of the Transactions of the Wagner Institute, the work being entitled "Explorations of the West Coast of Florida and in the Okeechobee Wilderness." Dr. Leidy in his introduction notes that "The well-observed facts of the report must greatly modify the opinions which have generally been held in regard to the geological construction of the Peninsula of Florida, and altogether Professor Heilprin's researches must be considered as an important contribution to science."

Heilprin's extraordinary activity and his large possession of that capacity for concentrated effort which has been recognized as the most sterling of all the forms of genius, was at this time evinced by the publication, almost simultaneously with the elaborate report on the Florida explorations, of another important outcome of his studies, the volume entitled "The Geographical and Geological Distribution of Animals." This work, which was published in the United States and in England as one of the volumes of the International Scientific Series, presents in a new

light and in logical succession the salient facts which connect the present and past distribution of animal life on our globe and thus a general review of the succession and relation of its various species. This production is in some respects quite unique and retains its place as a standard work on zoögeography.

In the following year, 1888, Heilprin published his book on "The Animal Life of Our Seashore," a popular and most attractive presentation of that interesting subject, and in the same year appeared his work on "The Geological Evidences of Evolution," an amplification of a series of lectures on this topic at the Academy of Natural Sciences. During that year also Professor Heilprin led a class of students of the Academy to the Bermuda Islands to study anew the nature of their coral reefs and singular hill formations and to more closely investigate their animal forms. The results of this journey were published in 1889 in a volume entitled "The Bermuda Islands: a Contribution to the Physical History and Zoölogy of the Somers Archipelago."

The next year, 1890, saw another of Heilprin's important books issue from the press. This was his "Principles of Geology," which forms the seventh volume of the Iconographic Encyclopædia. This book, as its title indicates, is an elucidation of the subject by means of pictures, in this case chiefly photographic reproductions direct from nature. In this regard the author states in his preface that "This work, it is believed, is the first of its kind to make extensive use of what may be called a natural method of illustration." He further observes that "the facts of nature should as far as practicable be represented in a truthful manner and not in a way that compels the mind to accept incorrect ideas. Apart from the benefits derived from correct interpretation, it can fairly be urged as a further advantage of photographic illustration, that it is apt to elicit a primary interest in the subject that is rarely developed by a diagram or even by a diagram and accompanying text." These statements indicate how completely, as well as quickly, Heilprin appreciated the possibilities of the then yet new art of half-tone photo-engraving, which has since then become the most extensively applied of all the graphic arts. The work was designed, as noted by the author, to meet the wants of the general reader without subjecting him to a study of the minute details which encumber most text books and it exemplifies in a high degree that admirable combination of vivid

elucidation and scientific exactness which is so marked a characteristic of Heilprin's writings.

In that year, 1890, Heilprin undertook an exploration of the Mexican Plateau to determine the true nature of that remarkable formation. His investigations disclosed the fact that this vast and lofty plateau is not the result of an upheaval of the earth's crust but has been produced by the accumulation, through ages of time, of material ejected by volcanos, evidences of whose activity are still afforded by the towering peaks of Orizaba, Popocatapetl and other extinct or inactive volcanos which fringe the edge of the elevated plain. Another interesting fact determined in the course of this exploration is the relative height of the two mountains named above, his ascents and accurate measurements of three of the highest peaks having determined the fact that Orizaba and not Popocatapetl was the highest point in Mexico. These studies were continued by Professor Heilprin during his visit to Mexico in 1906 and formed the subject of a volume which he had in preparation at the time of his death.

The new acquisitions of knowledge gained through his expeditions to Florida, the Bermudas and Mexico, led Heilprin to the idea of making the Philadelphia Academy of Natural Sciences a focus of scientific explorations. To this end he entered with zeal into the plan for Arctic exploration projected by Lieutenant Robert E. Peary, of the United States Navy, and promoted it to a successful issue. Heilprin's part in that enterprise cannot be better or more succinctly stated than by a quotation from Commander Peary's letter to the family of the Professor on the occasion of his death. He says: "My own obligations to and regard for him are particularly great. To him, more than to any one else, is due the activity of this country in Arctic and Antarctic work during the past fifteen years; for it was his interest and belief in my first project for Arctic work presented to the Philadelphia Academy of Natural Sciences in 1891, that led to the adoption of that plan by that organization, and the consequent awakening of interest in Polar matters in the years since then."

The history of these later Polar explorations is still in the making. One of its most dramatic episodes, and one that has no parallel except the finding of Livingstone by Stanley in the heart of Africa, was the meeting of Professor Heilprin and Lieutenant Peary, in 1892, in the midst of the bleak expanse of frozen

snow on the lofty surface of the Greenland ice-cap. Heilprin had accompanied Peary to Greenland at the outset of the latter's polar journey the year before and this meeting on the ice-cap was the culminating moment of the Peary Relief Expedition which Heilprin organized and led to its successful termination. The story of that expedition is contained in one of Professor Heilprin's most interesting books, "The Arctic Problem," published in 1893. In this work Heilprin, as usual with him, weaves his scientific data with entertaining narrative into the fabric of an instructive discourse, the volume being furthermore uniquely illustrated with colored plates and reproductions from photographs made by himself.

The exigencies of this relief expedition and the work entailed upon him in connection with the organization of the International Geological Congress, which met in Philadelphia in the fall of 1892, led Heilprin in the spring of that year to resign his curatorship at the Academy, thereafter to devote himself more completely to his literary work and to various projects of exploration. In 1893 he inaugurated the publication of a monthly magazine devoted to geographic science and entitled "Around the World," which was continued during that and the following year and became the prototype of the "Geographical Magazine," published by the National Geographical Society. Of this latter publication Heilprin was from the first one of the editors as he was also a member of the Society's Board of Managers. In 1896 the Geographical Society of Philadelphia, in the organization of which, in 1891, Heilprin had taken a leading part, and of which he had been President during the first four years of its existence, again elected him to its presidency and subsequently, in 1902-3, he again served in that capacity. In the summer of 1896 he made a journey to the Atlas Mountains of Algeria and Morocco to investigate a much discussed theory of a former glaciation of that region. His research resulted in removing all doubt on this subject, no trace of any glacial phenomena, either of a recent or early period, being found anywhere in the mountains. In that year also appeared his admirable text book, "The Earth and Its Story," a work which has met with great favor in educational circles.

His next explorations were made in the Klondike region and in Alaska. There he spent the summer season of the years 1898 and '99, his journey in the latter year extending from the Klon-

dike westward to Cape Nome. These expeditions were devoted to a scientific study of the auriferous deposits on the Yukon and of the gold bearing sands of the seashore north of Bering Strait, and formed the topic of a volume entitled "Alaska and the Klondike," which appeared in 1899.

After some months spent in Europe in 1900, Professor Heilprin, in conjunction with his brother Louis, undertook the arduous and exacting task of re-editing and reconstructing Lippincott's Gazetteer of the World. This work was begun in 1901 and completed in 1905, but was interrupted on his part by the exigencies of his several journeys to Martinique in 1902 and the following year and by the preparation of his books on the Pelée catastrophe. In 1903 he was called by Yale University to direct the department of Physical Geography in the Sheffield Scientific School. His work in that direction was greatly appreciated and was successfully continued to the last.

In 1903 Professor Heilprin was made the recipient of a gold medal by the Geographical Society of Philadelphia in recognition of his eminent attainments in geographical research, and in April, 1905, the great appreciation by the French scientific world of his signal services in the investigation of the volcanic phenomena in Martinique found expression in his having conferred upon him the high honor of appointment as Officier d'Acadmie.

In the spring of 1906 he made a journey into the interior of British Guiana to study the nature of the great equatorial forests of that region, his brief report of which as "An Impression of the Guiana Wilderness" appeared in the *National Geographical Magazine* for last June, only a month before the author's death. It was during that journey that he contracted the tropical fever which, through intermittent recurrence, gradually sapped his strength and paved the way for an acute attack of endocarditis, which eventually carried him to his untimely grave.

Besides his official connection with the National Geographical Society and with the Geographical Society of Philadelphia, already adverted to, Professor Heilprin was a member of the American Philosophical Society, of the Society of American Naturalists and of the Franklin Institute; President of the American Geological Society from 1891 to '98; a fellow of the American Association for the Advancement of Science, Vice-President of the American Alpine Club, President of the Association of

American Geographers, and a fellow of the Royal Geographical Society of Great Britain. As official representative of several of these bodies, he was a delegate to the International Geological Congress of 1906 in the city of Mexico.

As a recreation from his multifarious labors Heilprin cultivated his taste for painting and music. Several of his pictures have found places in exhibitions in this city and elsewhere, and he left behind him a series of admirable paintings in which several aspects of the Pelée eruption are vividly portrayed.

This sketch of Heilprin's inspiring career would be incomplete without a notice of his activity as a mechanician and inventor. In January, 1882, he was granted a patent on his invention for mechanically turning leaves of music at the piano, the device being also applicable for other similar uses, and in April, 1896, he was granted a patent on a ventilating car window which became the subject of investigation by the Committee on Science and the Arts of the Franklin Institute and was awarded the Edward Longstreth medal of merit in 1897. The working of these inventions he turned over to other hands.

Heilprin's character and the esteem in which he was held by all who were privileged to know him can well be summarized by another quotation from Commander Peary's recent letter, already referred to. He says:

"I have always found him ready, loyal, and superlatively able. When I named one of the greatest of Greenland glaciers and later one of the most northerly lands in the world after him, it was no perfunctory action, but a tribute of the deepest regard and friendship."

I have traced in but brief outlines this story of a most strenuous life, and have but inadequately pictured its restless activity. It was a life informed by a rare intelligence and enlightened by a brilliant intellectuality; a spirit inspired by that lofty altruism which seeks the improvement of mankind through widening our scope of knowledge and deepening our insight into the conditions of existence.

Angelo Heilprin lived but 54 years, yet within that shortened span he accomplished a work of such large moment as would well suffice the compass of the longest lifetime, a work which remains of permanent import to the world and which stands recorded in every library of science, in every language of civilization, in every quarter of the globe.

The Parker Steam Generator.

(Being the report of the Franklin Institute, through its Committee on Science and the Arts, on the invention of John C. Parker. (Sub-Committee: Francis Head, Chairman; J. M. Emanuel, Thomas P. Conard, Charles Day.)

(No. 2164).

The Franklin Institute acting through its Committee on Science and the Arts, investigating the merits of "The Steam Generator," invented by John C. Parker, of Philadelphia, reports as follows:—

This steam generator is a water-tube boiler, which at first glance resembles the Babcock and Wilcox type, but which on closer examination will be seen to possess distinguishing features which involve a new principle in the art of steam making. Briefly stated this may be termed the counter-current principle.

The aim is to avoid re-circulation of the water by so proportioning the length and capacity of the tube that complete evaporation is secured in one passage. In practice this is not entirely the case, and there is sufficient moisture in the tubes to prevent their overheating. The water enters the tubes where they are in contact with the coldest gases and travels toward the hottest gases, finally passing over the fire, by which time the water has largely turned into steam. By this arrangement there is always a wide difference of temperature between the water or the steam in the inside of the tube and the gases on the outside, which gives the most favorable conditions for heat transference.

Figure 1 shows in a diagramatic manner a boiler with the assumed temperatures marked in various places. At the top there is a dry steam chamber, a water chamber beneath it, a tubular passage extending downward from the water chamber, the lower end of which is connected to the dry steam chamber by a direct upcast passage. An opening between the chambers, controlled by a non-return valve, completes the circuit and equalizes the pressure. This valve prevents the water from lifting, due to a sudden heavy demand for steam, and a by-pass from the top of the water chamber prevents excessive differences of pressure during such periods.

A non-return valve at the entrance of the tubes prevents a reversal of the flow. In operation the water is fed into the lower chamber, filling the tubes, and seeks its level in the upcast. When heat is applied, the water in the upcast is soon driven out by the expansion of the steam. The result is that more water comes down to regain its level in the upcast and so the action becomes continuous and automatic.

The head which produces the flow is the vertical distance from the surface of the solid water in the lower chamber to the mixture of steam and water in the tube, and to secure this rate of flow is a matter of proportioning the length of tube and rate of combustion and is largely a question of correct design.

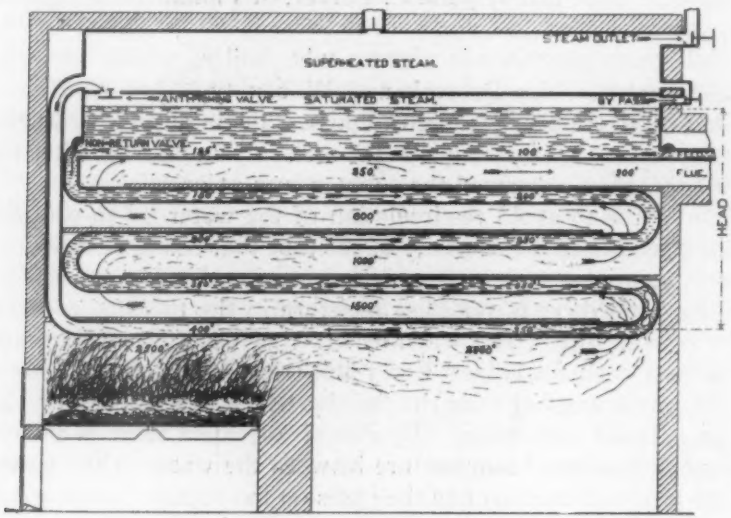

Fig. 1

Another claim of importance is the self-cleaning property of the boiler. This is accomplished by the rapid circulation through the tubes of a more or less solid body of water, whenever a drop in pressure occurs in the upper drum. This has the effect of removing whatever scale is formed and depositing it in the upper drums, where it is readily removed. This is quite successful in practice. Besides this, the boilers give fairly dry steam and have a flexible system of construction, avoiding any strains due to unequal heating.

Another feature of merit is the special form of hand-hole

cover on the box into which the tubes are expanded (shown in figure 2.) These are put in through the tube hole, and have a ground joint. On test they have remained tight under 1800 pounds pressure, at which pressure the tubes start to leak. This is three times the pressure which the ordinary cap, which was tested at the same time, stood.

A very interesting model, which is shown in figure 3, was exhibited in operation to the committee. It consists of one element ¼-inch in diameter by 25 feet long, including 24 tubes, glass upcast and 26 bends. The three tubes next to the door are glass

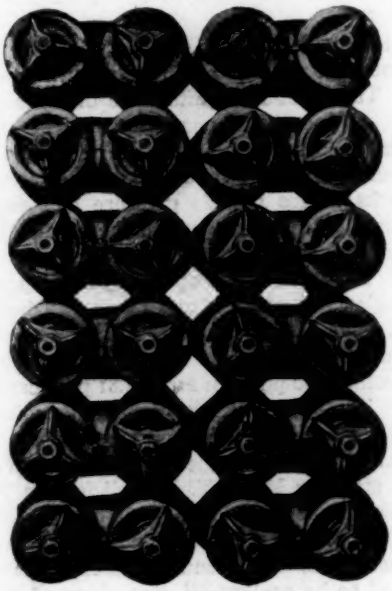

Fig. 2

and held in stuffing boxes, asbestos covered. The lowest stands the direct impingement of the flames with only steam flowing through it. There were six kerosene burners giving an intense blue flame, forced by air pressure, and the boiler carried thirty pounds of steam.

The first boiler of any size was built at Chester, Pa., and was rated at 175 H. P. A full description of this boiler and an account of tests by Prof. Spangler were given in a paper read before the Engineers' Club of Philadelphia, by Henry G. Morris, on April 6, 1901. This boiler has been in service since April 11,

1900, and we make the following extract from Mr. Morris' paper:—

"The lower drum is suspended in steel framework and supports the upper one on flanged necks. The front neck is merely a saddle with no openings into the drums, and is fastened only to the lower drum to allow for expansion of the drum independently. The rear neck, which forms the drain passage, is of steel, with the opening into the water drum brass-bushed, and is controlled by a conical drop valve. The by-pass connecting the drums at the front end has an offset (not shown) to allow for expansion. The drums are slightly inclined downward toward the rear for drainage and to prevent the sediment from going into the tubes a second time. The sediment settles at the rear end of the water drum, whence it is blown out.

"There are eight elements of 3-inch tubes, each having fourteen tubes 18 feet long and one tube 19 feet 6 inches long which connects with the upcast at the rear. The second and fifth rows of tubes are raised to provide access, but this has been found unnecessary. There are three rows of baffles, owing to the flue being at the front. The fire-brick air passages in the combustion chamber did not prove lasting, and were removed.

"This boiler works at 100 pounds pressure and supplies four steam hammers, several engines, and also heats some of the shops. It has 1760 square feet of heating surface, 36 square feet of grate surface, and is rated at 175 horse-power. It has been run up to 265 horse-power.

"Professor Spangler has made six tests of this boiler under normal working conditions. The equivalent water evaporated per pound of combustible from and at 212° F. was as follows: April 18th, 12.54 pounds; 19th, 11.65 pounds; 20th, 11.70 pounds; 21st, 11.81 pounds; 23d, 12.39 pounds; 24th, 11.05 pounds. The return tubular boiler alongside was tested and the result was 10.97 pounds under the same conditions.

"The first annual inspection of the boiler took place on March 31st. The inspection was made by Mr. J. T. Fennell for the Maryland Casualty Company, and a personal inspection was made by Mr. J. M. Lukens, Chief of the Bureau of Boiler Inspection for Philadelphia, accompanied by an assistant. The upper tubes were found perfectly clean, and some thin scale, which appeared to be peeling off, was observed in the bottom row. Mr. Fennell states that the tubes are in the same condition as he found them in his last inspection on December 9, 1900. The scale appears to peel off as fast as it forms, and is carried up and deposited in the drums."

The next boiler built was rated at 400 H. P., and was for the Philadelphia Rapid Transit Co., and was put in service July 26, 1902. This was placed among a row of water-tube boilers of the Babcock and Wilcox type, and was accepted after competitive trials had been made. An account of these tests was published in the *Engineering News* of November 27, 1902, from which the following is extracted:—

TABLE SHOWING RESULTS OF TESTS OF A BABCOCK & WILCOX AND A PARKER STEAM BOILER AT THE POWER HOUSE OF THE PHILADELPHIA RAPID TRANSIT CO., 13TH AND MT. VERNON, STS., PHILADELPHIA.

Items.	Test — No. 1; Sept. 1		No. 2; Sept. 2		No. 3; Sept. 17-18.		No. 4; Sept. 25-26.		No. 5; Sept. 30-Oct. 1.		No. 6; Oct. 16-17.	
	B. & W.	Parker.	B. & W.	Parker.	B. & W.	Parker.	B. & W.	Parker.	B. & W.	Parker.	B. & W.	Parker.
Duration of test, hours and minutes	6:49	6:30	12	12	24	24	24	24	24	24	24	24
Average steam pressure by gage (corrected), lbs.	142.15	142.15	140.8	140.8	143	143	142.14	142.14	142.8	142.8	142.0	142.0
" draft in flue, ins. of water	.76	.46	.658	.675	.77	.77	.5	.75	.76	.76	.75	.75
" draft above grates, ins. of water	.544	.464	.533	.408	.62	.50	.60	.50	.60	.52	.59	.50
" temperatures of escaping gases	614.0	410.5	509.9	414.5	536.5	442.8	576	448	575	443	556	448
" temperatures of feed water	80.4	80.4	81.65	81.65	71.0	71.0	72	72	68	68	61	61
Total coal consumed, lbs.	8,306	6,621	14,190	14,775	36,000	37,000	34,000	35,250	36,500	34,500	31,303	35,068
Moisture in coal, lbs.	Dry.	Dry.	Dry.	Dry.	4%	4%	4.5%	4.5%	4%	4%	3.5%	3.5%
Total dry coal, lbs.	8,306	6,621	14,190	14,775	34,560	35,552	32,470	33,664	35,040	33,120	30,207	33,831
Refuse in coal, lbs.	11.7%	11.7%	12%	12%	13%	13%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%
Total combustible, lbs.	7,334	5,846	12,487	13,092	30,067	30,930	28,152	29,187	30,374	28,715	26,190	29,331
Dry coal per hour, lbs.	1,218.5	1,018.6	1,182.5	1,231.0	1,440.0	1,400.0	1,353.0	1,402.67	1,460.0	1,380.0	1,258.6	1,409.6
Steam, percentage of moisture	.40%	.22%	.62%	.33%	.40%	.26%	.48%	.25%	.39%	.24%	.59%	.28%
Water from separator per hour	.....	.....	.....	.....	.....	.....	36.04	24.1	35.74	30.9	37.78	28.0
Total water pumped into boiler, lbs.	62,721	69,936	111,282	125,369	280,893	312,811	254,138	293,763	283,300	281,563	231,990	281,659
Equivalent evaporation, from and at 212° F.	74,261	72,148	131,647	148,311	335,386	373,496	303,187	350,459	339,110	337,031	279,316	339,117
Equivalent evaporation from and at 212° F., per hour	10,894	11,099	10,970	12,359	13,974	15,562	12,633	14,602	14,130	14,043	11,638	14,129
Economic results: Water actually evaporated per lb. of dry coal	7.55	9.20	7.84	8.48	8.12	8.79	7.83	8.73	8.08	8.50	7.68	8.32
Equivalent water evaporated per lb. of dry coal from and at 212° F.	8.94	10.89	9.28	10.04	9.70	10.50	9.34	10.41	9.67	10.18	9.25	10.02
Equivalent water evaporated per lb. of combustible, from and at 212° F.	10.12	12.34	10.54	11.41	11.15	12.07	10.77	12.01	11.16	11.74	10.66	11.56
Percentage of gain	.....	21.8%	.....	8.2%	.....	8.25%	.....	11.5%	.....	5.2%	.....	8.4%
Dry coal per sq. ft. of grate per hour	18.3	15.3	17.78	18.51	21.65	22.25	20.34	21.09	21.95	20.75	18.93	21.20
Water evaporated, from and at 212° F., per sq.ft. of heating surface, per hour	2.67	2.65	2.69	2.94	3.43	3.71	3.10	3.48	3.46	3.35	2.86	3.37
Horse-power (34.5 lbs. water from and at 212° F. pr hr.)	315.77	321.73	318.0	358.0	405.0	451.0	366.0	423.0	409.5	407.0	337.34	409.55
Heating surface per HP.	12.90	13.03	12.81	11.71	10.06	9.29	11.13	9.91	9.95	10.30	12.08	10.24
Horse-power per sq. ft. of grate	4.75	4.84	4.78	5.38	6.09	6.78	5.50	6.36	6.16	6.12	5.07	6.16

"In accordance with your request for information in regard to the contract tests of our boiler conducted by the Rapid Transit Co., in competition with one of their Babcock & Wilcox boilers, we forward you data, drawings, photos and samples of scale.

"We guaranteed that our boiler would evaporate more water under equal conditions of operations than their boiler. (2) That our boiler would not scale as rapidly as theirs. (3) That our boiler would wash out its own tubes automatically and constantly while in operation. (4) That our steam would be dryer, and that it would be impossible to cause it to prime. (5) That our tubes would not burn or blister. (6) That our hand hole joints could be made quicker and could be turned to stop a leak under pressure with safety.

"We agreed that the Traction Co. should conduct the tests and specified the following conditions:

"1. Both boilers to be put in perfect condition.

"2. To be operated simultaneously and under equal conditons.

"3. A separator and calorimeter to be connected to each steam pipe to intercept and measure the entrained water.

"4. Feed water to be unpurified city water from open heater or direct from mains.

"5. Both boilers to be operated at maximum power for 30 days of 24 hours each, without stopping; any leaks or other injury to be repaired and charged against boiler together with time lost.

"6. On the last day of trial the coal and water shall be weighed for 24 consecutive hours and the moisture in the steam deducted from the apparent evaporation, which shall then be computed for the full 30 days.

"7. Both boilers shall then be opened, and whatever repairs or cleaning are necessary shall be done and charged against each respectively.

"8. The net difference, if any in favor of the Parker steam generator, multiplied by 24, shall be deemed to represent the saving for two years, and the amount in dollars and cents, not exceeding * * * shall be due the Parker Engine Co. as a bonus in addition to the contract price.

"The Parker boiler was started on July 26, but owing to the coal strike the Traction Co. were not able to get their boiler in condition before Sept. 1, when the test was started.

"The tests of Sept. 1st, 2nd and 30th were conducted by Mr. Francis Head, assistant engineer of the company, in person, while in the others some of his assistants were present.

"No attempt was made to get extraordinary results. The regular firemen were used and one man fired both boilers through his full eight-hour shift. The only instructions given were to treat both boilers exactly alike and whenever anything was done to one fire the other was to be immediately treated likewise. No one meddled with the fire-doors but the fireman himself. The fires were cleaned at the end of each shift by the regular gang who took the usual time.

"The coal used was bituminous, run of mine, stated by the company chemist to contain 14,100 B. T. U. per pound. It was of a caking variety and had to be worked a good deal, and a great amount of clinker was

taken out at each cleaning, a good deal of time being lost in this respect and in getting the fire burning properly afterward. The coal was weighed on the same scale in the same barrow, which held 125 lbs. net, not full enough to spill in wheeling. The floor was swept up and four barrows delivered to each boiler alternately, making 500 lbs. net delivered at a time.

"To start and stop a test 500 lbs. of coal was put on the floor and the fire cleaned and the time and water taken when the fire was covered. The time of weighing the coal was taken but not the firing time.

"All openings to the boilers through which leakage might occur were blanked and the feed pumps set over their own tanks so that the leakage from them would not be lost. The water was weighed in tanks on scales resting on the suction tanks and the time of weighing and time of passing a mark in the suction tank was taken. The scales were found to agree by weighing water in one and then running it into the other.

"The boilers are connected to the same flue and steam main and each has an Eynon & Evans steam jet blower in the ash pit, but this was only used in the test of Oct. 16. This attempt to get over 500 H.P. out of the boilers by use of the blowers resulted in showing that the blowers hurt the soft-coal fire rather than helped it.

"The Sept. 1 test shows the unreliability of short test, since the Parker boiler showed an impossible advantage. On the other hand the Parker boiler got the worst of it in the Sept. 30 test, owing to a badly-clinkered grate. All the firemen complained about it and did not seem to be able to handle the fire in the usual way. Comparing this test with that of Sept 17th, it will be seen that the Babcock & Wilcox used more coal, while the Parker fell off 2,500 lbs. The firemen were unable to dislodge the clinker during the test without keeping the fire doors open for an excessive period, so the test was made of a bad job.

"On the 20th day of the 30-day run a defective expanded joint in the Parker boiler gave out and the boiler had to be shut down. The tube end had not been run past the shoulder in the box. The tube was pulled back into the box by running a length of pipe through it and screwing up on a flange at each end.

"On the 29th day of the run a tube was found blistered in the Babcock & Wilcox boiler, and it had to be shut down and a new tube put in. The clinker was chipped off the grate and this was the cause of the good showing in the Sept. 30 test. At the end of this test it was discovered that two more tubes were blistered in the Babcock & Wilcox boiler and had been leaking during the test.

"It was assumed that the leakage did not measurably swell the apparent evaporation of the boiler since it had shown about the same results in the test of Sept. 17.

"The Parker boiler was shut down on Oct. 9 and opened up in the presence of City Inspector Madden and representatives from the Baldwin Locomotive Works, the United Gas Improvement Co., the Penna. R. R. Co., the Edison Illuminating Companies and Mr. Francis Head for the Traction Co. Mr. Madden pronounced the tubes clean, although it was evident that scale had been formed in the bottom row as scattering patches

of it could be seen and 186 lbs. of it in small pieces was found in the front ends of the drums. About 4 ins. deep of mud was found in the water drums, while the steam drum was clean except for 33 lbs. of larger pieces of clean scale retained at the front end by the screen.

"The valves in the top boxes of each element were found clean and in perfect working condition.

"The scale appears to form entirely in the bottom tubes, and as soon as it attains any body peels off and is swept out of the tubes and thrown up into the drums by the force of the flow, exactly the same as in the Parker boiler at the Roach shipyard, Chester, Pa., which has been running now for two years and a half without any cleaning of the tubes except by the boiler itself. The mud is found to settle toward the middle of the water drums and an angle has been placed over the drum blow-offs so that the mud is now blown out very efficiently.

"The price of coal at the time of the tests being abnormal, $3 per ton was agreed upon as a fair basis for computation for bituminous coal at the fire doors. On this basis the saving shown by the Parker boiler over the Babcock & Wilcox computed according to contract was as follows: Sept. 1, $6,149; Sept. 2, $2,224; Sept. 17, $2,863; Sept. 25, $3,765; Sept. 30, $1,829; Oct. 16, $2,534.

"It was understood, of course, that to get this saving the boiler must be run at full power for the full time.

"As the lowest figures were far above the limit of the bonus and all the other claims were conceded, the company paid the Parker Engine Co. the full amount of the bonus on Oct. 10.

"The test of Oct. 16 was run to see what the boilers would stand without injury, but the blowers failed to add to the power, and this test fell far short of the results on Sept. 17, when the average for one of the eight-hour shifts ran up to 470 H.P. on the Parker boiler.

"The accompanying table gives the results of the tests. The heating surface of the two boilers tested was as follows:

	B. & W.	Parker.
Heating surface in tubes, sq. ft.	3,761	3,985
Heating surface in drums, sq. ft.	314	209
Heating surface, total sq. ft.	4,075	4,194
Grate surface, sq. ft.	66.5	66.5

"The samples of scale taken from the Parker boiler, submitted to us with the above letter, are all about 1-16-in. in thickness. Why the scale should flake off in this boiler after reaching this thickness and not continue to accumulate, as happens in other types of water-tube boilers, is a difficult question to answer. Apparently the only reason that can be found is the velocity of circulation through the lower tubes, which is very much in excess of that in any other design of water-tube boiler which we now recall."

This boiler is in use at the present time, and another competitive test made during the spring of 1903 showed over 5 per cent.

in favor of the Parker boiler, even after the Babcock and Wilcox had been thoroughly cleaned, while the "Parker" had never had its tubes brushed out.

During the time this boiler has been in service, 18 months, there have been but three tubes replaced, one of which was cut in being expanded into the boxes and one other had a slight crack caused by work done on it previous to this period of test. Four tubes have pulled out of their boxes, and as three of these occurred in one element, it was found to be due to a defective check valve.

This boiler is at the 13th and Mt. Vernon Sts., power station, and was built out of a three-drum boiler of the Babcock and Wilcox type, the middle drum of which was raised to serve as the steam chamber, the water level being maintained in the other two. Curved tubes were put in the bottom row, so as to get the upcasts up separately to the steam drum at the front end. In the later designs, straight tubes are used. This boiler has been examined while in operation and while laid off for inspection by members of the sub-committee and many prominent engineers, who have satisfied themselves that the tubes were free from scale, which appeared to collect in the drums, from which it could be shoveled out together with the mud which had settled there.

The satisfaction given by this boiler and its advantages in economy and in keeping free from scale have caused the Philadelphia Rapid Transit Co. to have six more built, with 6500 sq. ft. of heating surface each. Some of these are now in operation. These boilers have two 54-inch drums, which are divided by a horizontal diaphragm, forming the steam and water drums in one shell. All the tubes are straight and quite accessible, and special facilities are provided for blowing off the flue dust from the tubes by steam jets, which are built into the setting. Two similar boilers, with 8730 sq. ft. of heating surface each, have been put in operation at John B. Stetson's factory, Philadelphia. There are also three small boilers in use, one of 100 H. P. in Chester, Pa., and one of 200 H. P. in Philadelphia, and one in Michigan.

Figure 4 is a longitudinal section of the boiler as now built. Figure 5 shows how the front junction boxes may be separated to replace a tube. The boxes above the tube to be replaced are lifted five or six inches.

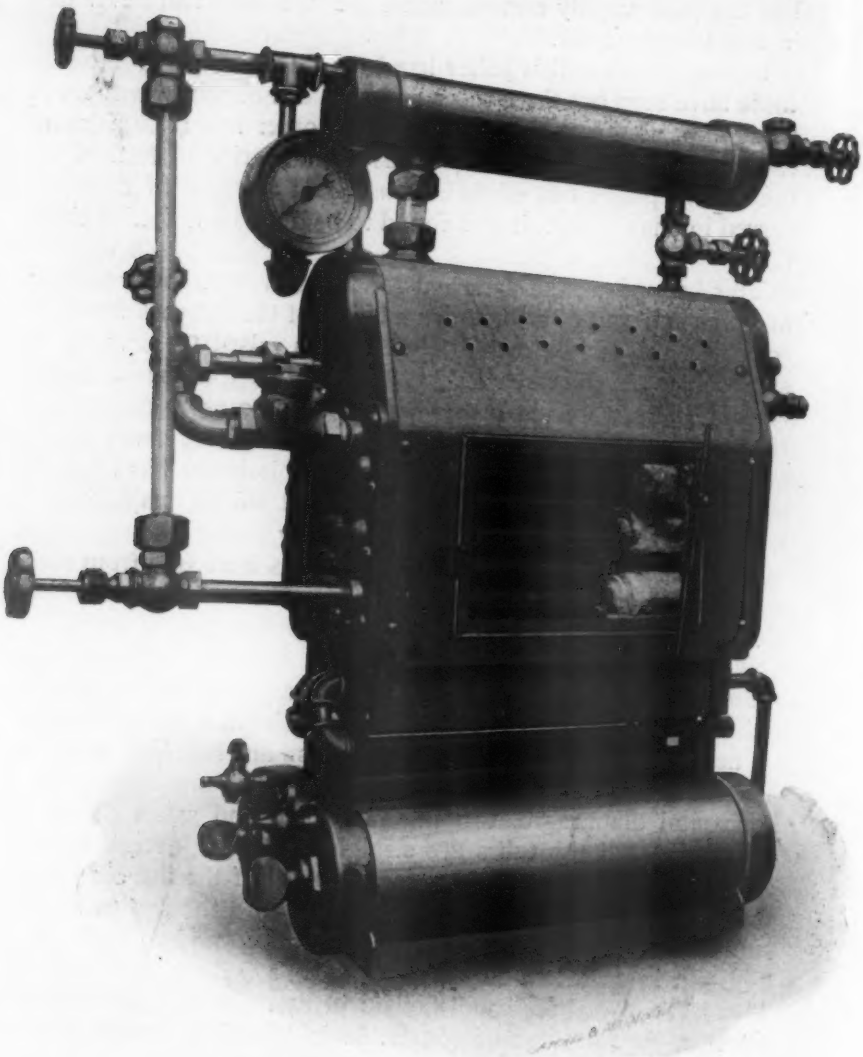

Fig. 3

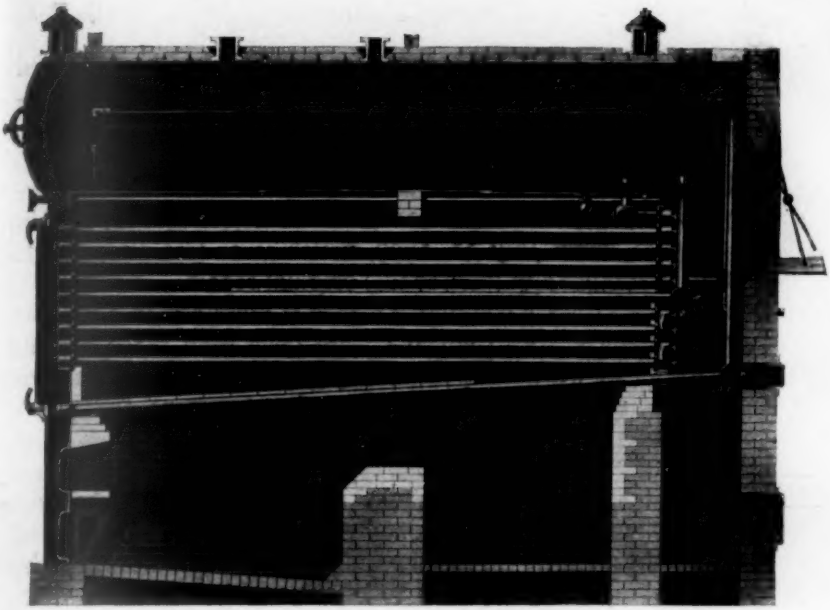

Fig. 4

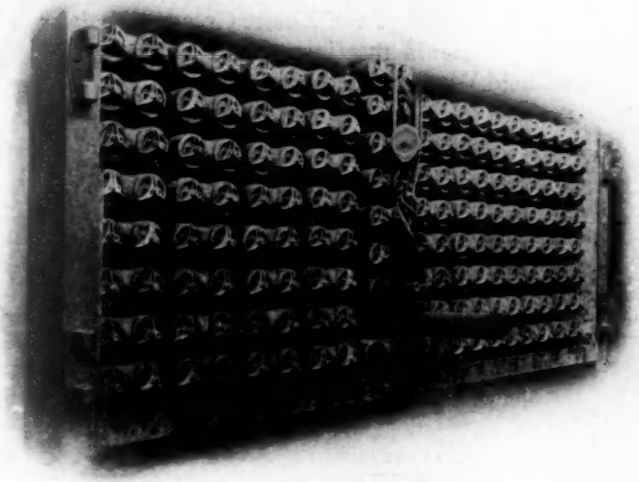

Fig. 5

In the Parker boiler the economizer principle has been applied in a water-tube form of construction, which embodies all the advantages of this well-known type, and to these advantages have been added self-cleaning features not possessed by older types.

The essential features of forced circulation are broadly covered in U. S. Patent No. 608,218, dated August 2,1898, and in No. 628,606, dated July 11, 1899, which is of less importance, copies of which are appended to this original report.

In conclusion, your committee deems it most remarkable that after the many years in which boilers have been made and in many forms in which they have appeared, each of which presented some novelty of construction or improvement, that there should be room for anything new in this well-worn field.

An examination of the various types, beginning with the plain cylindrical boiler, the return tubular and last the water-tube, will show that, while great strides have been made on the score of safety and economical performance, by decreasing the size of the heated unit and increasing the proportion of heating surface to grate, up to the present there has been no radical change which would allow of the highest thermal efficiency.

In recognition of the invention of an improved water-tube boiler by John C. Parker, and of his additions to our knowledge of the Art of Steam Generation, the Franklin Institute recommends to him the award of the Elliott Cresson Medal.*

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, March 2, 1904.

ATTEST: WM. H. WAHL, *Sec'y.*

A BIG SPRING.

No State in the Union has larger or more numerous springs than Florida. Many of them form good-sized streams from the start, and some of them are navigable. The largest spring in the State, and one of the largest and probably the best known in the United States, is Silver Spring, which is located six miles east of Ocala. This spring forms the source of the Oklawaha River, a tributary of the St. Johns, and steamboats traversing the river enter the spring basin, which has an area of several acres. The water is from 25 to 30 feet deep and is wonderfully clear, appearing absolutely colorless.

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*Since the adoption of the above report about 50,000 H.P. of these boilers have been placed in service. F. H.

(Stated Meeting held Wednesday, September 16, 1907.)

Camden's Artesian Water Supply Is Not Derived from the Delaware River by Infiltration.

By Prof. Oscar C. S. Carter.

The subject of underground water is one that requires knowledge of a special kind. It is not a question that can be worked out in the library or a question that an engineer or chemist can decide offhand. The problem of underground water in all its intricacies is primarily a question for the geologist who has given special study to dynamical and structural geology, or better, to that division of the subject known as stratigraphy. He may be an excellent authority on fossils and know comparatively little about underground water; he may be an authority on topography or an expert mineralogist and lithologist and yet be incapable of giving the simplest advice about the circulation or supply of underground water. A geologist with modern chemical training such as is given by your universities to-day can readily determine whether a water is hard or soft or even if it be unpotable from large excess of organic matter, but these are questions primarily for the chemist, and a complete up-to-date analysis of water in which the percentage of all the constituents, even the most minute, are determined, requires skill and care.

The chances of getting underground water, the probable yield, whether it will be constant, and many other questions that arise; the geologist can often solve if he has made a special study of this subject, but something more is necessary besides this theoretical and technical knowledge and that is a practical knowledge gained by studying the records of artesian wells drilled in different parts of the country as the work progresses. By artesian well records we mean records kept of the depth of well, kind of rocky strata passed through from top to bottom, number of crevices struck and whether they yield water or are dry crevices, height of water in the well, number of gallons yielded per hour, how

much the water drops in the well on pumping several hours or days, &c. It seems wonderful to the layman that a driller when drilling an artesian well 1500 feet deep, or deeper, can tell the number of crevices struck and whether they yield water to the well or are dry, and yet the mystery is not so great when we know that the heavy drill is attached to a long rope which is lifted by the engine; the driller merely turns this occasionally so that the drill makes a round hole. When the drill strikes an underground crevice it drops and the driller feels it. When the sand pump or bucket is put down to clean out the drillings and there are none there, he knows they were washed away and he has struck a stream in a crevice of running water. He knows the depth of rope in the well and how much it dropped when the crevice was struck and hence the width of the crevice. Camden is a city located in New Jersey along the Delaware River opposite Philadelphia. It is the starting point for the railroads that lead to Atlantic City. The water supply since 1853 was drawn from the eastern channel of the Delaware, which flow between Pettys Island and the Jersey shore, but as the Delaware receives the sewage of Philadelphia and the towns above, and the tide rushes up the estuary known as the Delaware Bay and then up the river as far as Trenton the source of supply was finally abandoned owing to the increase of typhoid cases and other forms of sickness. Artesian wells were then looked to as a source of supply and a series of test wells were put down just north of Delair, a small town two or three miles north of Camden, along the Delaware. These wells furnished an excellent supply of potable water. It was then determined to draw the entire supply for the city of Camden from this vicinity. Accordingly about 100 acres of meadow land just north of Delair along the Delaware River between Pensauken Creek and Pochuck Creek were purchased. This land lies between the Camden and Amboy R. R. and the Delaware River. In this tract within a stone's throw of the river during 1897 and 1898 there were put down one hundred and one artesian wells. Eighty-nine of these wells were drilled in the ordinary way and twelve put down by the hydraulic process. Some of the details about the wells are taken from the Annual Report of the State Geologist of New Jersey for 1898 and were collected by Lewis Woolman, to whom much credit is due for his industry in collecting records of New Jersey's underground

water supply. The twelve wells in the southern tract were provided with strainers at the bottom thirty to forty feet in length. They were of galvanized iron pipe provided with $\frac{3}{8}$-inch holes and covered on the outside with brass cloth. The remaining eighty-nine wells had strainers twenty-four feet long with par-

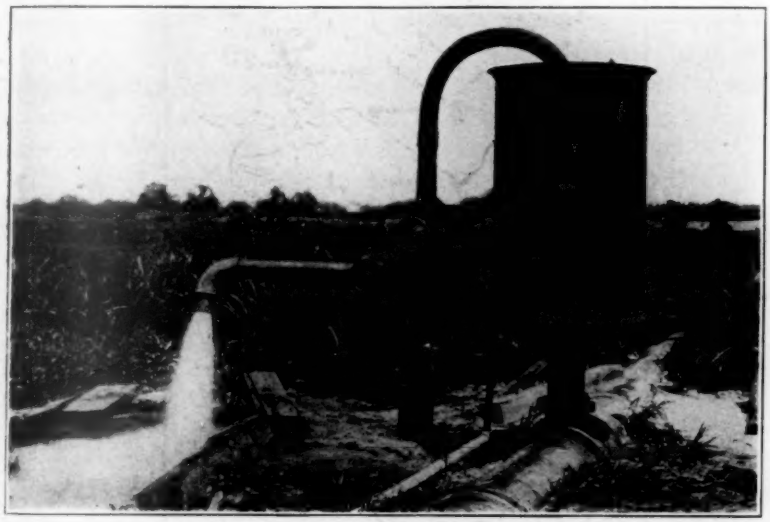
U. S. Geological Survey contour map of a part of New Jersey, showing location of artesian wells between Morris and Delair.

allel slots $\frac{1}{4}$ of an inch apart. Reference is made to these strainers because they were afterwards changed. It is understood that these wells are lined with iron pipe which is lowered as the well is drilled and the strainers allow the water to enter at the bottom and prevent the well clogging with sand or clay. The wells

are classified into shallow and deep wells. The shallow ones are from fifty to seventy feet in depth and the deeper ones from ninety to one hundred and twenty-five feet. The author is well aware that some authorities would like to limit the term artesian well to deep wells that flow. But this is not the general acceptation of the term at all among authorities at the present time. Artesian wells are named from the province of Artois in France. Hundreds of artesian wells are put down in this country (United States) every year, some of them from 1000 to 2000 feet in depth and probably not five per cent. of those put down in the Eastern States are flowing wells. The water rises to within ten to thirty feet of the surface and is readily pumped the rest of the way. In the West, flowing artesian wells are more common, and it is no uncommon sight to see an enormous stream feeding an irrigation ditch or forming a small artificial lake where thousands of cattle are watered. Neither is it desirable to restrict the term artesian to very deep wells. Many shallow wells that are drilled in the ordinary way or by the hydraulic process furnish an abundance of water, often more than the deeper wells. The difference between an artesian well and a dug well is so clear that it is not necessary to restrict the term artesian to flowing wells. In order to get a clear conception of New Jersey's artesian wells we must have a general idea of the topography of the State. Most of these wells are in the southern half of the State, known as the coastal plain, a low, flat sand plain which we travel over from Camden to Atlantic City. Northern New Jersey is mountainous. The Kittatinny Mountains, belonging to the Appalachians, extend from Pennsylvania through Northern Jersey. They are steep sided, even crested ranges over 1500 feet above tide with wide valleys between. The next zone south and east of the mountains are the Highlands, a series of block-like masses, not peaks; the elevation is about 1200 feet above tide. The next zone south and east of the Highlands is the Piedmount plain, commonly called plateau. The topography varies; in some places it is low plateaus, in others it is a rocky, rolling country. The elevation is about 800 feet above tide. These zones comprise the northern half of the State, which is mountainous or hilly. There are plenty of rivers and creeks and water power is ample, hence artesian wells are not so necessary in Northern New Jersey. But in Southern Jersey the rivers flow sluggishly along the sandy, coastal

plain. There are few cascades or waterfalls, hence practically no water power for manufactories unless dams are built, and the topography is not favorable for them. The creeks are far apart and small, hence towns, villages and farms often depend wholly on artesian water. Along the coast where the tide ascends the lagoons and tidal estuaries and makes brackish water in the rivers this is especially the case, and Atlantic City, Ocean Grove and in fact all the seaside resorts use artesian water. The so-called coastal plain of the United States begins at Long Branch and extends along the Atlantic coastal and Gulf States to the Rio

Water Department Report, 1906



New Air Well at Morris.

Grand River in Texas. It is a country of sands, marls and clays and is not rocky in the popular acceptation of the term. The plain varies from sixty to one hundred miles in width. This plain does not end at the beach but continues under water out to sea for from fifty to one hundred miles according to locality. It is known as the submerged coastal plain. The increase in depth is very gradual, in fact the fall is only five or six feet per mile, which would make an almost perfectly level plain to the eye, if the ocean should recede and the land become elevated. In fact

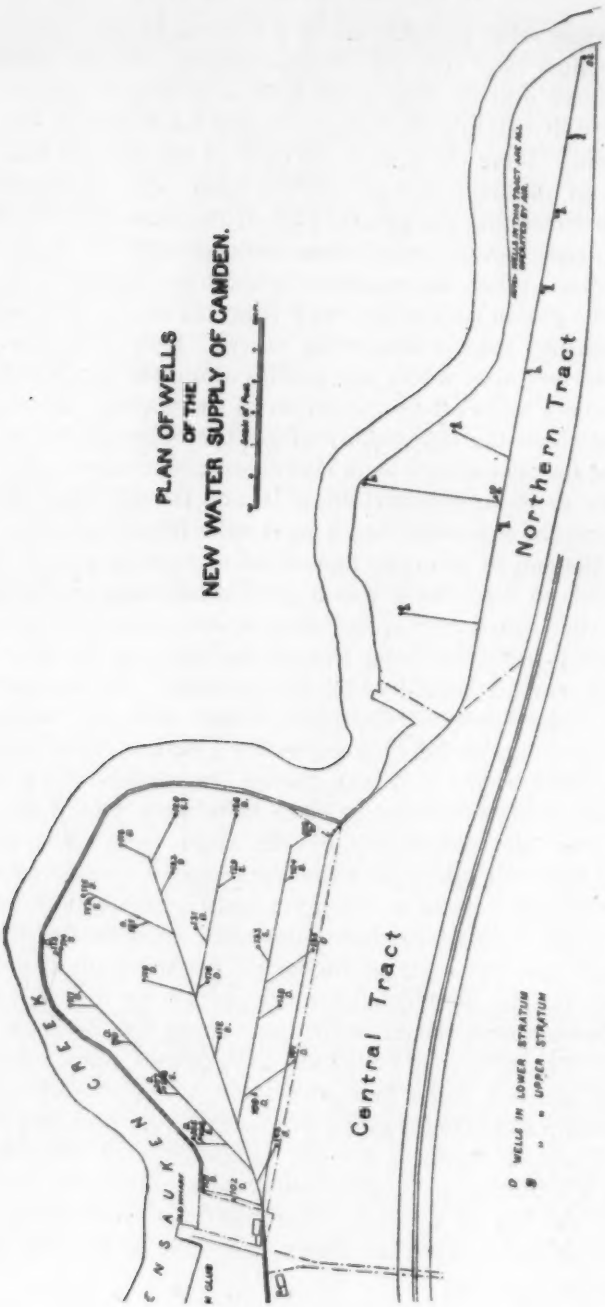
we have to travel 100 miles off Sandy Hook before we reach the 100 fathom line, but when we come to the end of this great submerged continental platform the depths are no longer shallow but abyssal. Now there are three divisions of this coastal plain in Southern Jersey. The marl belt, the hilly belt and the sandy plain. When we leave Camden for Atlantic City we soon enter the marl belt. Marl is a greenish earth made up of shells and

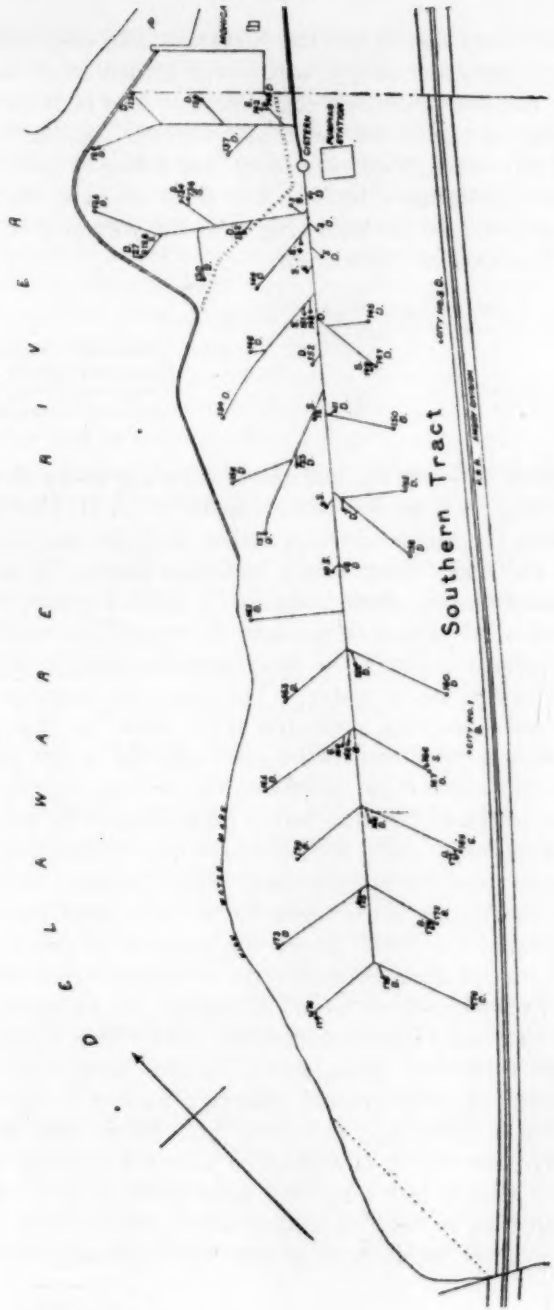
Map of New Jersey, showing the prinbipal topographic divisions of the State.

clay. The lime of the shells makes it a valuable fertilizer for cereals and grasses. There is a little phosphoric acid and potash in green sand marl. The Marl Belts extend from Raritan Bay to Salem on the Delaware River. The belts are from five to fifteen miles wide and vary in thickness from two inches to twenty feet. The beds dip or slope towards the ocean. When we leave the marl belt we come to the hilly belt. These are generally sand

hills of gentle relief and they act as a water shed and separate the streams which flow into the Atlantic Ocean. In the marl and hilly belts we find the best farm land in Southern Jersey. Between the hilly belt and the ocean stretches the long, low and level sandy plain. Here the soil, on account of the sand, is unusually poor and in marked contrast with the other belts; farms are few and far between and the greater part of the plain is covered with unbroken pine forests and a dense undergrowth of high ferns called brake. When we examine the sand we see that it is ocean sand. The gravel beds miles away from the shore, now used for macadamizing, tell an interesting story. They were the beach lines of former ages where the pebbles along the beach had their sharp corners worn off by the action of the waves. Enough has been said about the topography of Southern Jersey to make it plain that the formations were laid down under water; the oyster and other shells in the marl show it, and the old beach lines of pebbles and the fine white beach sand miles inland prove it.

At the end of a certain age of the cretaceous period, known as the Dakota Age, there was a great subsidence of the eastern coast of the United States, and what is now known as the coastal plain, which begins at Long Branch and ends at the Rio Grande in Texas, was submerged under the Atlantic. The southern half of Jersey just described was under water and the waves beat against the ridge of hills known as the Chestnut Hill Ridge just back of Philadelphia. It was during the cretaceous period that the upper, middle and lower marl belts were laid down under water after the subsidence of the coast line. The marl at Mullica Hill and other places is one mass of fossils, containing such well known forms as Exogyra and Gryphœa, both members of the oyster family, also Belemnite casts, a member of the cuttle fish order and the casts of numerous marine snail shells (Gasteropods.) The Philadelphia rocks, which we find at Chestnut Hill, Germantown, Bryn Mawr and along the Schuylkill from Gray's Ferry up beyond Lafayette, are gneisses, mica, schists with belts of igneous rocks here and there. This rocky floor of micaceous rocks extends under Southern Jersey and may even extend under the ocean as far out as the edge of the submerged continental platform. It can readily be seen that this rocky floor formed the bed of the ocean and the clays and marls of the cretaceous period were laid down upon this rocky floor which is


PLAN OF WELLS
OF THE
NEW WATER SUPPLY OF CAMDEN.
Northern Tract
Central Tract
CAMDEN
CAMDEN
WELLS IN LOWER STRATUM
" " UPPER STRATUM


DELAWARE RIVER
Southern Tract

now buried many feet below the surface. The deep well at Atlantic City (2000 feet deep), which was drilled from the pier in the ocean, did not reach this rocky floor. The beds of clay and sand resting on top of the marls are younger because they were laid down afterward; they vary in age according to position, from the surface Quaternary beds to the deep miocene beds of the Tertiary period. In the following table the youngest beds are on top and the oldest at the bottom:

Quarternary Period:—Sand and gravel.
Tertiary Period:—Sand and gravel.

Cretaceous Period.....	Age, Manasquan or upper marls.
	" Rancocas middle marls.
	" Monmouth lower marls.
	" Matawan clay marls.
	" Raritan plastic clay.

The plastic clays of the Raritan rest on the rocky floor. The accompanying ideal section from a paper by N. H. Darton, of the United State Geological Survey, makes clear the position of these beds and the rocky floor which underlies them. It is evident from the section that these beds dip or slope towards the ocean. The second ideal section shows how the rainfall in Southern Jersey filters down through the sand until it meets a bed of clay which is impervious to water. The sand bed confined between two clay beds becomes saturated with water so that when an artesian well is put down to the sand bed, the water rises in the iron pipe and sometimes overflows, providing, of course, the column of water in the sand bed is higher than the well. These general preliminary facts are necessary to a clear comprehension of Southern Jersey's underground water supply. The plan of the wells above Camden is taken from the Annual Report of the State Geologist for 1898, shows the position of the wells in the southern, central and northern tract and shows that they are all near the Delaware River or its tributary, the Pensauken Creek. It shows that they are all connected with lateral pipes which empty into four main pipes, which, in turn, empty into an enormous cistern or underground reservoir known as the receiving well, which is thirty-five feet deep and thirty feet in diameter From this reservoir it is forced to Camden through a 36-inch main over 19,000 feet long and then by a 30-inch main about 13,000 feet long to South Camden, where there is a stand pipe on elevated ground which pipe is 110 feet high and thirty feet in

diameter. The only misleading thing about the drawing showing the plan of the wells are the numbers attached to each well. These are not depths of the wells but are numbers that were given to them in the order that they were put down. It is evident that the wells are put down in the sand along the river. Several years ago at a monthly meeting of Philadelphia geologists Mr. Woolman was explaining the underground water horizon of New Jersey by means of a large colored chart which was exceedingly instructive and useful and had been prepared with great care from many records of artesian wells. The statement was made that Camden artesian water supply at Delair was derived from the Delaware River by the water filtering through the sands. During the discussion the almost unanimous opinion was that Camden's water supply was merely Delaware water that had filtered through the sands. The author dissented from this opinion and at a future meeting presented proofs to support the opposite view,

Section of coastal plain in Southern Jersey, showing relations of artesian wells and water horizons

which is that Camden's water supply does not come from the Delaware but from the higher ground east of the Delaware where it filters down through the sand towards the river valley, and that the composition of the Delaware water is entirely different and that analysis shows them to be totally unlike. Some contend that this is a matter of grave import to Camden, inasmuch as they went to great expense to avoid the Delaware water and that they do not want it even if it filters through the natural sand beds along the river. Of course there is this to be said about it, the conditions are entirely different from those of an artificial filter bed; the artificial beds can be cleaned and they are not used until they are ripe, that is, until a slimy vegetable growth accumulates on the top layer of sand. It is this slimy growth which does the work and filters out the disease bacteria as well as the harmless ones. It is a well known fact that we could not pack even very fine sand close enough to remove germs that it takes a microscope of high power to detect, but when the slimy growth accumulates

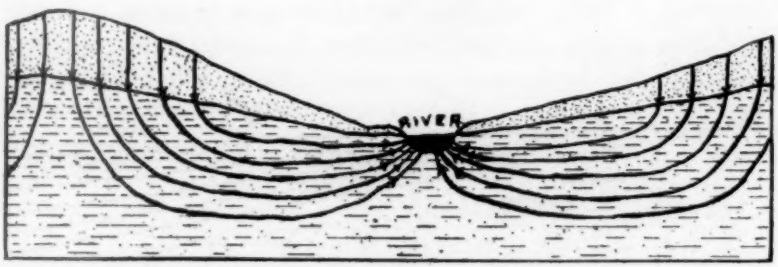
the bacteria are destroyed. Whether these thick sand beds between the wells and the river would filter the water thoroughly, providing it might drain towards the wells, is a question that will bear investigation; the author inclines to the view that they would. The people of Camden, however, need give themselves no concern on that score, as the water comes from a different direction, for the following reasons: First, the composition proves them to be entirely different. These analyses were furnished by the City Engineer in 1900; they were made some time previous:

Artesian Water from Test Well.	
Total solids	30.
Chlorine	8.6
Free ammonia	0.15
Albuminoid ammonia	0.12
Nitrites	None.
Nitrates	2.210
Silica	.827
Iron	.1
Alumina	.298
Lime	.443
Magnesia	.16
Sulphuric acid	.118

Delaware River Water, Taken 150 feet off Fishers Point.	
Total solids	110.
Chlorine	5.0
Free ammonia	0.04
Albuminoid ammonia	.10
Nitrites	None.
Nitrates	Trace.
Condition	Slightly turbid.
Color	Slightly yellow.
Odor	Faintly musty.
Reaction	Alkaline.

The first analysis was made by Gilbert Landis; the second by Dr. Henry Leffmann. They are calculated in parts per 1,000,000. The total solids in the artesian water are low, less than one-third of what they are in the Delaware water. The lime and magnesia are particularly low; this makes it a very soft water and explains why no scale forms in the boilers since they have been using artesian water. This was not the case where Delaware water was used, as a scale formed then. The hardness of the artesian water is only 1.78 degrees, which is very much less than even Schuylkill water. This is very unusual, because artesian waters in Pennsylvania are generally harder than river waters. The author has made a study of between thirty and forty wells drilled in Southeastern Pennsylvania and published the records of most of them and their waters are generally harder than river water, particularly the wells drilled in the Triassic sandstone of Bucks and Montgomery counties. Some of these wells yield water twice as hard as Schuylkill water, although much of the hardness disappears after the well has been in use for several months. The second proof that it is not filtered Delaware water is: That not over six weeks elapsed after these wells were started and millions of gallons were pumped for Camden before it was found

that the farmers' wells east of Delair within a mile ran dry. These were the ordinary shallow dug wells. Many farmers were obliged to put down deep artesian wells. Now if Camden's supply merely filtered in from the Delaware, the farmers' wells east of Delair, some of which are on high ground, would not be affected in the slightest. The artesian wells in the northern and central tract extend to Pensauken Creek and even the farmers on the other side of the creek and beyond complained that their dug wells ran dry. These facts clearly prove that the water comes from the higher ground east of the Delaware and that the direction of flow of the underground water is towards the Delaware and not from the Delaware outward. This fact is very clearly

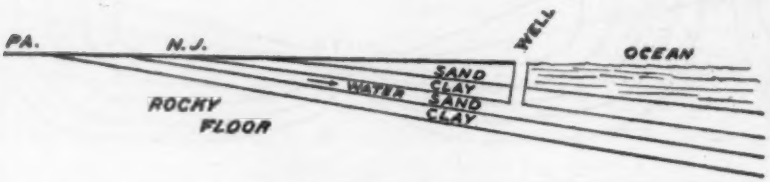


Diagrammatic section, illustrating seepage and growth of streams.

brought out in an article on the "Principles and Conditions of the Movements of Ground Water," by F. H. King. See 19th Annual Report, part II, page 95, U. S. Geological Survey, where he states: "There is a widespread general belief that the level of standing water in the ground is indicated by the level of the waters in the rivers and lakes of the district in question, and that wells must be sunk to those levels before water will be reached by them. It is even commonly thought that the water which supplies the local wells of a region actually seeps into the soil and rock from the beds of rivers and lakes. So far is this common impression from being true that its exact opposite is the real expression of the facts. The surfaces of rivulets, brooks, creeks, streams, rivers and lakes lie below the level of standing water in the ground adjacent to them and from which almost everywhere water is steadily but usually flowing slowly into them. There is a slow but general seepage from the surrounding higher lands."

To quote still further: "It is plain, therefore, that streams winding through the lowest levels of valleys, in regions of humid climates, must receive increments to their volume of water step by step as they move along. It is further evident that low-lying flat areas between higher ground may be made and kept wet by the slow rise of water from beneath as it is forced upward under the hydrostatic pressure developed by the accumulation of water percolating down through the surrounding higher land and in the figure is represented in diagrammatic form the directions of movement of the ground water as it passes downward through the porous soil and outward from beneath the higher areas tc seek an outlet in river channels or in the beds of lakes."

In Philadelphia's new water supply the water is taken from the Delaware at Torresdale, then filtered by sand filtration and then carried by an underground conduit ten feet seven inches in diam-



Ideal section, showing alternate beds of sand and clay.

eter and 100 feet below the surface to Tacony where it is piped to Philadelphia. The statement was made in print and attributed to a prominent engineer that the conduit would leak less when the level of the Delaware was high and leak more when the Delaware was low. The idea was there would be more pressure of underground water on the outside of the conduit when the Delaware was high. From what we have just stated the seepage is in the other direction.

The third proof that it is not filtered Delaware water is: The artesian wells that furnish the water for Camden are not affected by the rise and fall of the tide of the Delaware. As explained before all of these wells are comparatively near the Delaware and if it was merely filtered Delaware water the water in the wells would rise and fall with the tide. Mr. Ridpath, an artesian well driller, who put new strainers on these wells, is authority for the statement that the wells are unaffected by the tides.

It is interesting to note that the artesian wells at seaside resorts

along the coastal plain rise and fall with the tide. In the Annual Report of the State Geologist of New Jersey for 1898, pages 76 and 79, are found the following statements:

"Tidal rise and fall of the water in artesian well at Ventnor, south of Atlantic City—well 813 feet deep—

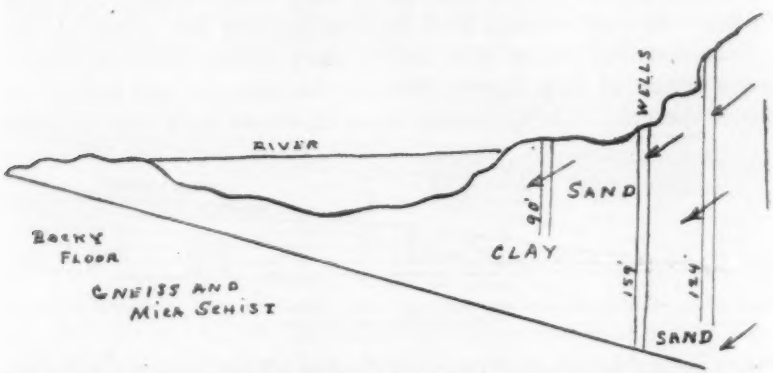
"After the completion of the well and before the connection with the water supply system a series of observations were made covering a period of three weeks, showing a tidal rise and fall of water in the well regularly following the rise and fall of water in the ocean, and approximately three-fourths of an hour later. These observations were made by James C. Calvert, the Postmaster at Ventnor. A study of his measurements show that the difference between two consecutive tides varied from $7\frac{3}{4}$ to $14\frac{1}{2}$ inches. In the artesian well at Avalon, 925 feet deep, at the northern end of Seven Mile Beach, observations were made during a period of eight days respecting the tidal rise and fall of the water therein. The difference between consecutive high and low

Ideal section, showing how salt water may exert back pressure and force fresh water in the well to rise and fall with the tide.

tides in this well varied from $10\frac{1}{2}$ inches to $15\frac{3}{4}$ inches. Our observations the past season definitely show that the height of water in this and other artesian wells along the coast rises with each high tide to a greater or less elevation according as the tides on the shore are greater or less in height, and similarly falls with each low tide, to a less or greater height in the casing in accordance with a less or greater fall of the tides off shore."

The Avalon well was interesting because it was a flowing well. The water rose about eight to nine feet above the surface, varying in height with the tides and flowed seventy-five gallons a minute. These facts are in accord with what has been said about the seepage or circulation or underground water. It is from the land towards the ocean; were it otherwise we would get salt water in the wells instead of fresh. In fact, there is not the slightest doubt if we were to put down an artesian well in the ocean five miles from the shore, in certain places on the submerged coastal

plain, that we would obtain fresh water after the drill had penetrated the deep clay beds and entered the water horizons in the underlying sands. The various deep clay beds are impervious to water and would keep the salt water from getting to great depths. As an illustration that these beds of clay and marls are continuous for great distances, we might mention that the marl beds which come to the surface in middle Jersey slope or dip towards the ocean and at Atlantic City the borings from the deep artesian wells show that these same marl beds are 800 feet below the sea. The reason the water in wells at seaside resorts rises and falls with the tide may be explained as follows: There is no doubt that the sand horizons which furnish the water, even if they are



No well defined and continuously connected clay beds near the river and wells to make a vertical section. The continuous beds of sand and clay are found to the eastward.

buried at great depths between beds of clay, must appear on the ocean bottom somewhere, even if it be at great distances from the coast in deeper water. This being the case we can understand how the pressure of the sea water would cause the fresh water to rise.

This is merely an ideal section and is not intended to represent beds ending at the edge of the continental platform. How far out these beds extend and where they make their appearance on the ocean floor is not known.

If this rise and fall of water in wells at seaside resorts is due to tides, and we see no reason at present to doubt the statement, because the wells were tested immediately after drilling and before the water was piped to the cities, then we know of no other ex-

planation of the cause of how the tides make the water rise and fall in the well than that given in the diagram.

To return to the Camden wells. It is impossible to make a section showing continuous and alternate layers of sand and clay in the vicinity of the wells because such continuous layers of clay are not found in the Delaware River Valley like they are to the eastward. The Annual Geological Report of New Jersey for 1898, page 110, states: "Between the water-bearing strata of the shallow and those of the deep wells we have not been able after a careful study and the plotting of vertical sections to make out any well defined and continuously connected clay beds; there are, however, many beds of clay between the two horizons which vary in color, being white, red or yellow. In thickness they measure from a few inches to ten feet or more. These clay beds seem to the writer to probably be lenticular in shape and to be interbedded at varying depths between the more open sands and gravels and to be more or less limited in extent so that they cannot be traced continuously across the sections of any great number of wells."

FIRE-PROOF CONSTRUCTION.

A great fire, resulting in the sacrifice of hundreds of human lives and the loss of many million dollars' worth of property, is possible in every city of the United States. The calamities of Chicago and Baltimore might be duplicated in New Orleans or St. Louis. An earthquake in New York equal in intensity to the one in San Francisco would cause an appalling loss of life and property. Investigations made by three of the most competent structural experts in the country have led them to the conclusion that there are no absolutely fire-proof buildings. Not that fire-proof buildings are impossible, for, according to these experts, structural materials may be so selected and used that adequate fire protection is practically assured; but in the effort to cheapen construction in order to obtain greater interest on investments, owners of buildings have neglected or ignored perils to lives and fortunes.

Soon after the San Francisco earthquake, the Interior Department at Washington, through the United States Geological Survey, assigned to Richard L. Humphrey, Secretary of the National Advisory Board on Fuels and Structural Materials, and Prof. Frank Soule, dean of the College of Civil Engineering of the University of California, the task of investigating the action of the fire and earthquake upon so-called fire-proof buildings. At about the same time the War Department assigned a similar task to Capt. John Stephen Sewell, Engineer Corps U. S. A., whose reputation as an expert on fire-proof building construction is international. After a thorough investigation these officials have prepared a careful report, which

has just been submitted to the Interior Department and will soon be published by the Geological Survey. The conclusions presented in this report are of great interest and value.

Mr. Humphrey, emphasizing the fact that the lessons of the Chicago and Baltimore fires are still unlearned, declares that a remedy for existing conditions can be had only by the enactment of strict building laws which will compel fire-proof construction. Professor Soule estimates that the earthquake caused directly less than 10 per cent. of the total loss at San Francisco, and that of the subsequent and indirect effects—the paralyzing of the water supply and its distributing system, the starting of a fire impossible to extinguish with the means at hand, the death of at least 500 persons, the destruction of $500,000,000 worth of propety, and the remoter damages to business, commerce, and labor—nearly all might have been prevented by wise foresight and provision. Capt. Sewell points out the fact that fires and fire tests have proved conclusively the inadequacy of commercial methods of fire-proofing as at present applied.

The recommendations of the experts as to the essentials of fire-proof construction are definite and positive. High, steel-framed office buildings properly braced, are declared to be stable and reliable, and concrete and reenforced concrete structures are placed high among materials well adapted to withstand earthquake and fire, while hollow tiles and hollow concrete, although not in the past universally successful, may be so employed as to yield most satisfactory results. Concrete floors with metallic mesh reenforcements are strongly recommended for strength and fire resistance, and wire glass, metallic rolling shutters, and metallic sash have proved such excellent fire protectors that wise economy demands their use in every important building. Other materials and measures equally important are enumerated, and it is believed that their adoption, while involving increased cost of construction, will insure permanence of structure and at the same time greatly reduce rates of insurance.

A TWENTY-FOUR-CENTURY OLD TUNNEL.

Evidence exists that a work similar to the famous Simplon tunnel, but on a smaller scale, was executed some twenty-four centuries ago. Owing to the bad state of the water supply of Jerusalem, the King ordered a reservoir to be made at the gates of the city, to which water was to be brought from various springs. The Shiloh tunnel, by means of which water was brought down from a source to the east of Jerusalem and poured into the pool of Siloam, was 1080 feet long, and is in a straight line. It has been learned that work was commenced at both ends of the tunnel, and the direction was altered a number of times. The floor of the tunnel is finished with great care. The width varies from 1.9 to 3 ft., and the height from 3 to 9 ft. There is much speculation as to how these engineers gauged their direction so well as to be able to recognize and correct errors in alignment, as was certainly done.—*Iron Age.*

Section of Physics and Chemistry.

(Stated Meeting held Thursday, October 17, 1907.)

Classification and Uses of Cement.*

By Samuel S. Sadtler,

Member of the Institute.

With a view of classifying and studying the subject of cements, the writer has prepared the following discussion. This subject is such a broad one, embracing a wide range of chemicals and raw materials, that the scope of this paper can not go beyond a general treatment of the subject.

Besides cements in the narrow sense, there are other preparations which may also be defined and discussed.

A *cement* is a plastic or liquid substance used to join surfaces. It becomes firm or solid on setting.

A *lute* is a plastic material used for preventing or stopping leaks and is generally used for temporary purposes. Its setting is generally of such a character that it may be easily removed.

Pastes and *mucilages* are fluid substances used for uniting paper and cloth or fastening them to surfaces such as wood or metal.

The purposes for which this class of substances are employed are so many that there is hardly any line of work that is not in a notable measure depending upon them. It is difficult to recall any industry not requiring one or more of them.

Wood workers, masons, plasterers, plumbers, bookbinders, machinists, the metallurgical industries, manufacturers of chemi-

*Read by title.

cals, all industries where power is a large factor, scientists and householders are constant users of cements.

It can hardly be said that there is any dearth of information as to what might be used in special cases or that there is any difficulty in procuring suitable materials for compounding, but it has been thought desirable to treat the subject in a systematic way. This might help persons to choose a cement, to compound it, and to get the best results in its use.

The fact is that there are hundreds of formulas published for making cements, where dozens would serve if careful selection were made by some one and the result properly classified. Of those now published, too much is claimed for some, others are practically impossible, a large number are unnecessarily complicated or use expensive elements where cheaper ones would serve, such as the use of ale or brandy as media of solution. These substances may do the work required, but simpler ingredients naturally suggest themselves and the old formulas should be revised accordingly, provided tests show that the changes are safe ones to make.

SETTING.

To properly use cements it is quite important to understand the rationale of their action. With this knowledge, if the action characteristic of its setting does not proceed satisfactorily, modifications of temperature, dilution or proportions may be made and much trouble saved thereby.

The phenomena of setting may be differentiated as follows:

1. Evaporation, loss of water or other solvent.
2. Hydration, taking on the elements of water.
3. Cooling.
4. Oxidation.
5. Vulcanization.
6. Ordinary chemical action.
7. Combination process.

1. *Evaporation.* In cases where setting takes place by evaporation there are various considerations to be noted in respect to both solvent, solute materials and insoluble filler if any.

The chief consideration is of course as to whether the materials in solution or combined solution and suspension are chemically and physically resistant to solution, corrosion or abrasion

incident to their use. This matter is, however, too full of detail to be taken up at this time. As to the solvent, however, something may be said here.

Layers of cement should not be so deep as to seriously hinder evaporation, especially if the solvent is water. When water is used, unless the time of setting is not important, heat is generally present to expel it, or some corrective filler used, such as Portland cement or plaster. As the solvent goes off cracks are likely to develop if the mixture is too thin. Fibrous materials such as noted below under the head of fillers are useful for holding it together, and if the body of the cement is of soft material such as oils or soft pitch it is especially desirable to have some inert filler present whether fibrous or not. When the solvent is not water, choice of various organic solvents can often be made. In general methyl (wood) alcohol and ethyl (grain) alcohol dissolve soaps, free organic acids and some of the resins, while the other solvents dissolve, more or less perfectly, fats, oils, some resins, pitches and asphalt.

The most important solvents are here given in the approximate order of volatility (with boiling points), solvent power and cost:

Volatility.	*Solvent Power.*	*Cost.*
Sulphuric Ether...35°C.	Sulphuric Ether.	Sulphuric Ether.
Carbon di-sulphide.46°C.	Chloroform.	Ethyl Alcohol.
Acetone.....56°C.	Carbon di-sulphide.	Chloroform.
Chloroform .....61°C.	Carbon tetrachloride.	Acetone.
Methyl Alcohol...66°C.	Turpentine.	Carbon tetrachloride.
Carbon tetrachloride .78°C.	Glacial Acetic Acid.	Glacial Acetic Acid.
Benzol .....80°C.	Benzol.	Turpentine.
Petroleum benzine 100-150°C.	Toluol.	Denatured Alcohol.
Toluol .....111°C.	Acetone.	Wood Alcohol.
Glacial Acetic Acid 119°C.	Petroleum Benzine.	Benzol (straw color).
Turpentine .....156°C.		Toluol (straw color).
	Methyl Alcohol.	Benzine.
	Ethyl Alcohol.	

A great deal could be said about these solvents. Each one in turn may be the best for certain substances. The classification as to solvent power is very crude but may be of use at times.

Most of these substances are extremely inflammable and form explosive mixtures with air. There are two notable exceptions, however—chloroform and carbon tetrachloride—especially the latter. It will neither burn nor support combustion.

2. *Setting by Hydration.* In this case crystalline substances form *en masse*, by the taking up of water. It is desirable to have as nearly the total amount of water required as possible to secure the greatest density and strength. There should not be too much inert material present to keep the particles of the setting substance apart. The more finely divided the inert material, the less can be used, as the particles of cement itself must coat all the particles of inert material or be between them to effect a bond. If the particles of inert material are of the same degree of fineness only an equal amount, as compared with cement, can be used. When properly graded as to fineness from five to eight times as much by volume of the filler may be used.

The time for setting may be somewhat reduced by using warm water and very little if any excess and may be retarded by having an excess and by the use of small amounts of certain chemicals, alkaline substances, for instance, delay the setting of Portland cement and plaster. In some cases the entire amount of water cannot be used at once or it dries out somewhat, so that subsequent wetting is necessary.

3. *Setting by Cooling.* In this class are considered cements and lutes which are applied in the melted state, such as resins, waxes, bituminous bodies, solid fats and sulphur. The great advantage of using materials in this way is that there is no loss in density as is generally the case where the setting takes place by evaporation. The work they are applied to should be hot, however, or the setting is interfered with.

If the pieces of apparatus to be joined are small it is usually well to heat them well, as applying the cement hot is not enough to insure a fused union of cement and work.

Inert substances are almost invariably used in admixture to make the cement harder, stronger, fill voids and to cheapen it. Clay, sand, asbestos, cement, plaster, whiting, etc., are used in this connection.

Sometimes there is a subsequent chemical action, as when acid resins are used with fillers of a more or less basic character, such as metallic oxides or carbonates.

4. *Setting by Oxidation.* This may take place in oil used or in powdered metal. In the case of oil there is an effect of hardening and consequent setting. With metals it causes an expansion due to increase of volume. The commonly used oils acting in

this way are Chinese wood oil, linseed oil, rapeseed oil and fish oils. In the case of Chinese wood oil, the oxidation is so energetic that it is generally best to mix it with some other oil. Linseed oil is almost always previously "boiled" before use and rapeseed oil "blown."

With regard to the metal powders, iron is the chief one used, although precipitated copper has been used and other metals might be for special purposes. The iron used is invariably the powder resulting from the crushing and sorting of cast borings, filings or millings. They should be nearly free from oil, and the cement has the greatest expansive power when in a finely divided condition.

The value of these cements depends on the expansion taking place in a confined space, such as holes or cracks in castings. This expansion may be so powerful as to break or shatter the object upon which it is used. In such sases it can be diluted with clay or cement. When the holes in a casting are well filled with concentrated iron powder moistened with water containing a very little salt or salammoniac the particles adhere so firmly and the actual oxidation is so limited in actual amount, that the casting can be finished and not show where it was mended. Furthermore, the cement is not dislodged by any ordinary means.

5. *Setting by Vulcanization.* This takes place where fresh rubber is used as a cement in conjunction with sulphur or certain compounds of the same and heated to about 120° C., which renders the rubber insoluble, firm and causes it to lose its stickiness. Vegetable drying oils may be used, such as rapeseed and linseed oils, with sulphur chloride, dissolved in carbon disulphide, as a vulcanizing agent. Hydrochloric acid gas is liberated in this reaction and so zinc oxide or a similar base is generally used to neutralize the acid. In the vulcanization of rubber itself, such precaution must be taken when sulphur or sulphur chloride is used.

6. *Setting by Chemical Action.* Under this classification we have several of the most useful cements known. In most cases, however, the action is too rapid, so that setting takes place before the cement is in position. Dilution of the active ingredients is the general remedy for this. There are also specific ones. As examples of the most useful cements, the oxy-chlorides may be mentioned, which remain nicely liquid or plastic for ample time to use

and then set up very strong and hard. The well-known glycerine-litharge cement acts nicely in this respect. Cements formed from silicate of soda and oxides of lime, magnesia, zinc, etc., and those formed by the action of their oxides on casein and albumen do not act so well. They are liable to set up too soon and be crumbly when set up.

7. Setting by Combined Action. The most prominent case of this kind is the setting of glue. In the first place when used it is a melted mass that on cooling has fair strength of coherence and adherence. Then, however, as the water is absorbed by the wood or other material being cemented, it becomes stronger until very great strength is developed when free of water.

Other cases are when a solvent or heat is used with a resin, boiled oil, etc., mixed with a metallic oxide such as lime. There is then the combined action of the evaporation and the formation of new compounds or so-called metallic soaps.

INERT SUBSTANCES.

These useful, harmless substances do not make a cement, but so many formulas differ only in the choice of them that it might be supposed they did. Sometimes a little work is required of them, as when there is a little water to be taken up. Plaster and Portland cement serve this purpose. Zinc oxide and other basic substances, while mainly serving as fillers, absorb acid in addition. In most cases, however, no action of this kind is required and it is merely a matter of giving body or other physical properties.

A classification of fillers may be made as follows:

Corrective.	*Porous.*	*Strength.*	*Finely Divided.*
Portland cement.	Infusorial earth.	Asbestos.	Cement.
Plaster of Paris.	Magnesium carbonate.	Hair.	Clay.
		Plush trimmings.	Plaster.
Zinc oxide.		Cloth.	Gypsum.
Lime.		Tow.	Whiting.
Whting.		Oakum.	Silica.
Magnesia.			Powdered glass.
			" fluorspar.

COMPOSITION OF CEMENTS.

Cements that have come into use to any extent may be placed in classes according to their composition as follows:

1. a. Rubber solutions.
   b. Gutta percha solution.
   c. Pyroxylin solution (collodion.)
   d. Gum resin solutions (such as mastic and copal).

2. Silicate of soda and neutral fillers.

3. a. Flour pastes.
   b. Starch pastes.
   c. Dextrin pastes.
   d. Gum solutions (such as arabic, tragacanth).

4. a. Plaster of Paris.
   b. Portland cement.

5. a. Bitumens (pitch, tar, asphalts, etc.).
   b. Resins (resin and gum resin in melted state).
   c. Sulphur.
   d. Shellac.
   e. Rubber and gutta percha, melted or thinned with oil.

6. Iron powder compositions.

7. Drying oil mixtures.

8. Oxy chloride cements.

9. Glycerin and sugar compounds of lead.

10. a. Glue.
    b. Casein.
    c. Albumen.

11. Cements made from metallic oxides and strong acids.

12. a. Vitreous and vitrifying mixtures.
    b. Clay and asbestos, etc., with water.

Class 1—a, b and c are especially waterproof, tough and tenacious. d is not so tenacious but answers the other requirements, adheres better to smooth surfaces, has greater hardness when set, and is transparent in thin layers in which it is frequently used for optical purposes. a, b and c are generally made up with fillers to prevent the formation of voids on the evaporation of the solvent.

Class 2. Not waterproof, but form very dense, hard and strong lutes. Especially good for hot gases, in which case the water of the silicate can go off. They are useful for organic solvents and stick only too well to glass. Suitable fillers are

barytes, whiting, silica, powdered glass and powdered fluorspar. The three latter probably slowly react with the silicate with beneficial results.

Class 3. Are used for fastening paper and cloth.

Class 4. This is a most important class. a is generally used without filler, although frequently mixed with alum, etc., for purposes of increasing the density. It is used for filling hollow articles, moulds, etc. b is the most used of all cements. It is made into concrete for building purposes, etc. For use in small amounts it is not successful as the water dries before it can set.

The making of cement concrete waterproof is an art not understood by all. The main points to be considered are to have the voids as few as possible and the dense coating on the side the water would enter. Neat cement is probably most used for this denser coating. It should be used as strong as it will flow well into crevices and hot if possible. The condition of the work and the kind of cement are important. It is waterproofed best when fresh, and if washes such as silicate of soda, skimmed milk and casein solution are used an over-limed cement is desirable. Magnesia cement has been recommended for this purpose, but the chloride is liable to soak in and not combine properly with the oxide.

Class 5. This is a very important class, if the number of formulas are a criterion. The materials must be applied in melted condition. The marine glues are made from materials of this class. Sulphur is much used by itself and sealing wax is also of this class.

Class 6. The use of this material has been referred to above.

Class 7. Putty and red lead compositions are among the best known cements. Boiled linseed oil is invariably used and if rosin is dissolved in it and metallic oxides mixed therewith a much thicker composition is obtained thereby than otherwise. When very much oxidized by exposure to heated air in their films and mixed with powdered cork, etc., linoleum can be produced.

Class 8. Oxy-chloride of zinc has been used for dental purposes and forms a very dense, strong, stone-like cement. Oxychloride of magnesium is, however, more used, as the ingredients are cheaper. It is used for uniting particles of stone either for

refacing the same or make an artificial stone, for making compositions with saw dust for a kind of floor tiling.

Class 9. This class is a valuable one, embracing the well known glycerine and litharge cement, much used for joining glass to metals, etc. It is waterproof, acidproof, gasproof and not attacked by organic solvents.

Class 10. Casein and albumen form very strong compositions with lime, zinc oxide, etc. They set up very quickly, so must be used at once. They are more in the nature of lutes than cements properly considered.

Class 11. The combination of zinc and other oxides and phosphoric acid stands for this class. It is much used by dentists and forms a hard, dense, waterproof substance.

Class 12. This class includes glass powders or glass forming mixtures that bind surfaces at high temperatures.

With a view of choosing a cement only the most general statements can be made here. In two previous papers* details of formulas have been given by the writer.

The following suggestions may be of use however, the numbers referring to the classification on page:

Hot surfaces, 2, 4a, 9, 10 and 12.
Elastic, 1a, 1b.
Water and steam, 5a, 5b, 5e, 6, 7 and 9.
Strength, 2, 4b, 8, 9, 10a and 12.
Expanding, 4b and 6.
Quick setting,
Acidproof, 1a, 1b, 1c, 2, 5a, 5b, 5c, 5e, 9.
High temperature (moderate), 4b, 6.
High temperature (excessive), 12a, 12b.

COST OF MATERIALS.

The writer has known of many instances of people being disappointed at preliminary inquiries into the cost of materials used for experimentation. In some cases probably abandoning a line of work, as they thought that it would not be economically possible on a large scale.

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*Jour. Franklin Inst., May, 1904.
*Trans. Eng. Club of Phila., 21 (1904), 315.

The druggist or other retailer must frequently put up the few ounces of chemicals asked for in bottles or cartons at the price per ounce the goods sell for per pound in large lots.

For the benefit of those however who do not follow the market quotations a brief table of the costs of the most used materials is here given. These figures are mostly fluctuating but close enough to be a general guide. They are figures for ton or drum lots:

Material.	*cts. per lb.*	*per gal.*
Acetic acid	12	
Acetone	19	
Alcohol, denatured		40
Alcohol, wood		40
Albumen, blood	30	
Albumen, egg	75	
Alum	2	
Alum (conc.)	2	
Ammonia (aqua)	6	
Asbestos	5	
Asphaltum (ref.)	4	
Barytes (floated)	1	
Bayberry wax	28	
Beeswax	40	
Benzine		18
Benzol (straw)		25
Borax	9	
Carbon disulphide	7	
Carb. tetrachloride	12	
Casein	9	
Chinese wood oil	8	
Chloroform	35	
Clay (finer grades)	½-1	
Copal (sorts)	60	
Dextrin (corn)	3	
Formaldehyde	9½	
Gum arabic	10-35	
Gum mastic	50	
Gum tragacanth	45-70	
Glue, hide	12	
Glue, bone	9	

Material.	*cts. per lb.*	*per gal.*
Glycerin	14	
Gutta percha	2.50	
Iron oxide	3½	
Iron powder	5	
Japan wax	14	
Lamp black	6-35	
Lime	⅛	
Litharge	8	
Linseed oil		45
Magnesite (calc.)	2	
Magnesium chl'ide	1½	
Nitro cellulose	50-1.00	
Pitch		3.50 per bbl
Plaster of Paris		1.50 " "
Rape seed oil		75
Red lead	8	
Rosin	2	
Rubber	1.50	
Shellac	45-65	
Soda-silicate	¾	
Soda, caustic	2	
Sulphur	3	
Sulphuric acid	1½	
Stearic acid	14	
Stearine	7	
Tannic acid	40	
Turpentine		61
Whiting	2	
Zinc chloride	5	
Zinc oxide	6	

DETAILS OF USE.

It is a matter of importance that a cement be used under favorable conditions. It might seem superfluous to say that the "work" should be clean, but in large factories there is frequently a great deal of dust, moisture, grease, etc., that deposits on pipes and other places where joints are to be sealed.

Air films should be displaced by heating the "work." This prevents a chilling of the cement, which might fail to adhere if not

fused into the surfaces where applied. Some writers have insisted upon this heating as a *sine qua non* of success. But it is manifestly impossible in some cases. An alternative to this is to paint the surfaces to be joined with a solution of the chief constituent of the cement. A benzol solution, for instance, of pitch, oil, rosin, etc., can be used. If silicate of soda, glycerine or magnesium chloride are the liquid elements, water can be used as solvent for this painting.

Surfaces should fit as closely as possible before the cement is used. Use as little cement as possible.

Preservatives such as sodium salicylate, benzote or an essential oil may be used in small amounts for pastes and mucilages that would spoil otherwise on exposure. It is a good plan to have some cements or lutes most used for any particular line of work made up ready to be mixed or applied.

LABORATORY OF SAMUEL P. SADTLER & SON,
PHILADELPHIA, PA., OCTOBER 1, 1907.

CANADIAN BOUNTY FOR ELECTRIC SMELTING.

TORONTO, April 6, 1907.—A resolution was introduced into the House of Commons by the Finance Minister on Thursday declaring it expedient to provide for the payment of bounties on pig iron and steel manufactured by electrical processes. The adoption of the resolution is, of course, not the same thing as the passage of an act on its third reading, but it is a practical certainty that the measure into which the resolution is to be turned will become law. Last week the opinion was hazarded in this correspondence that no special bounty for electrically-produced pig iron or steel would be proposed by the Minister, and the bounties provided for in this resolution cannot well be described as special. They are simply an application and a time extension of the bounties now paid upon pig iron and steel produced by established methods. The terms of the resolution are as follows:

That it is expedient to provide that the Governor-in-Council may authorize the payment out of the consilidated revenue fund of the following bounties on pig iron and steel ingots manufactured in Canada for consumption therein, when such pig iron and steel is the product of Canadian iron ores smelted in Canada by electricity, viz.: on pig iron manufactured from Canadian ore by the proces of electricity smelting during the calendar years: 1909, $2.10 per ton; 1910, $2.10 per ton; 1911, $1.70 per ton; and 1912, 90 cents per ton. On steel ingots manufactured by electric process direct from Canadian ore, and on steel ingots manufactured by electric process from pig iron smelted in Canada by electricity from Canadian ore during the calendar years: 1909, $1.65 per ton; 1910, $1.65 per ton; 1911, $1.05 per ton; and 1912, 60 cents per ton.

It is apparently the intention of the Finance Minister to give the manufacturers by electrical processes a clear four-year period of bounty assistance of exactly the same kind as that now remaining for the blast furnace and steel works owners. For pig iron manufactured by the regular method from Canadian ore to bounties, it will be remembered, are as follows: in 1907, $2.10 per ton; 1908, $2.10; 1909, $1.70; 1910, 90 cents.

For steel ingots of which not less than 50 per cent. of the weight is derived from pig iron made in Canada, the bounties are as follows: In 1907, $1.65 per ton; 1908, $1.65; 1909, $1.05; 1910, 60 cents.

It will be seen that the new bounties on electrically-produced iron and steel are to be at the same rate as those provided for iron and steel otherwise produced, the difference being that the four-year period for the electric products does not begin until 1909, whereas that for iron and steel produced by the ordinary methods began on January 1 last. It is probably assumed by the Government that the intervening period of twenty months is not too long to allow for the establishing of electrical smelters and converters. But should any begin operations within that time their output would be entitled to the current bounties of $2.10 and $1.65, respectively, on pig iron and steel ingots, however produced.

Besides the results of experiments carried on with the aid and under the supervision of the Government at Sault Ste. Marie, laboratory work elsewhere appears to have successfully demonstrated the feasibility of treating some of the most unpromising of Canadian iron ores by electrical processes. It is stated that while the tests at Sault Ste. Marie were in progress private parties were proving the practicability of the electrical smelting of titaniferous ores in Quebec. These parties are reported to be in touch with New York and London capitalists.

R. Turnbull, a Scottish engineer, who was associated with the experiments at Sault Ste. Marie, proposes to erect a plant at Welland, in this Province. He undertakes, if adequate bounties are granted, to have his plant in operation a year from next July. N. Thompson, who went from Canada to England last year, succeeded in interesting capital to establish an electric smelting plant at Bow, near London. He is now back in Canada and proposes, if sufficient Government aid is given, to form a company for the electric smelting of iron ores in British Columbia.—*Iron Age.*

LIGNITES IN IDAHO.

Lignites occur at a number of places in Idaho, but only within the last two or three years have any of these beds been extensively mined. Mining has been done in the Horseshoe Bend and Jerusalem districts, occupying the lower portion of a ridge between the Boise and Payette Rivers; in a district near Salmon City, in Lincoln County; and in one at the eastern edge of the State, in Bingham and Fremont Counties, where the Sublette fields of Wyoming extends across the State line. According to E. W. Parker, of the United States Geological Survey, the principal production in 1905 and 1906 was from the Salmon district, in Lemhi County, 4380 short tons having been mined there in 1905, and 4395 short tons in 1906. The total production for the State in 1906 amounted to 5365 short tons, having a spot value of $16,538.

(Stated Meeting held Thursday, October 17, 1907.)

The Jerseyite.

By Dr. E. Goldsmith,
Member of the Institute.

On the 30th of April, 1906, a fisherman of New Jersey saw a meteoric fire ball pass overhead with a hissing noise and, travelling up the Lower Delaware Bay, fall on the New Jersey shore.

He went to the point where he believed he saw it fall and found it at low water, about twelve miles north of Cape May Light.

He brought two pieces of it to the Academy of Natural Sciences of Philadelphia, where he wanted to learn of what the matter was composed. There, to his astonishment, he was told that the material was not of meteoric origin, because it has no external pitting and, as they believed, it had the appearance of a mill-cinder.

So the mineral was labelled and put into the collection. I confess that when the specimen was shown to me several months later it gave me the impression that it might be furnace slag. However, knowing from many years of experience that matter cannot be determined by mere inspection, I made up my mind to ascertain the true nature of the mineral by the crucial tests of physics and chemistry.

Prof. Pillsbury, to whom my thanks are due, kindly handed to me a part of the sample brought by the finder (whose name I think is North.) On observation it was found that the sides were furrowed by longitudinal crystalline impressions, indicating that it must have been heated and partially melted. At one end a mass of the same material apparently and of the same structure

is attached to the specimen at right angles, giving it the appearance of an artificial make-up.

The substance is brittle, and with the aid of a chisel and hammer a piece was broken off, ground plane on one side on an emery wheel in a machine shop and polished on plate glass with rouge and water until light was reflected; then, after washing, etched in diluted nitric acid.

The result of this treatment was the appearance of the Wittmaustedten figures; and, on more minute observation, it became evident that the whole mass was crystallized.

Now this structure, viz:—the Wittmaustedten figures, has never been observed in a mill-cinder or in furnace-slag from either a blast or open hearth furnace, nor in any manufactured iron or steel, nor any alloy whatsoever, for I have had the opportunity of observing many hundreds of specimens of all sorts of metals and their alloys under the same condition of polished and etched surfaces and never detected the presence of any crystallization which could be compared with the Wittmaustedten figures. Therefore, when these figures appear under the conditions as stated, they are an absolute proof that we are dealing with matter derived from space, i. e. extra-terrestrial.

This test has been known for nearly a hundred years, and has been overwhelmingly proved to be correct. There are few objectors to this rational test.

For my part, I feel confident in stating that the Wittmaustedten figures occur only in matter derived from interstellar space.

The hardness of this meteoric stone is about the same as that of microcline, that is = 6. The specific gravity was found to be = 3.636. The color of this crystalline mass is nearly black. The polished surface of the specimen reflected diffused light grayish white; sunlight as well as the white light from the Welsbach mantel burner gave the same peculiar gray reflection. That a modification of the rays of white light had been effected by the black shining surface was evident; but, what was the cause of this difference? Evidently some of the spectral rays must either have been absorbed or had never entered the material; in either case the reflected rays differ! In order to ascertain this point, I had recourse to the spectroscope. It is evident that if all the rays of sunlight had entered the material they would be reflected. Let us see what the spectroscope answered.

When the light is reflected from the polished specimen into the narrow slit of the collimator, then passed through a diffraction grating and observed with the telescope in focus and strictly optical line, the centre of the phenomenon has the same appearance, that is to say, grayish-white rays are visible; but, when we search on the left and right from the centre, only a partial spectrum, the green and some blue rays become visible. The green ray was measurable; the blue not. From the centre to the green ray the arc was $=3^{0}2^{1}$ approximately, hence the wavelength $\lambda = 529 \times 10^{7}$. Comparing this result with the published Angstrœm's Charts, we find that the ray measured is in the neighborhood of the Frauenhofer line E.

If the slit of the collimator is further opened, then yellow, orange and red rays enter the field. But what became of the indigo and violet rays? They are simply absent; they never entered the material and could therefore not be reflected. We have the answer now why the reflected rays from the black polished surface were grayish. True, white light must have all the seven rays of the spectrum, otherwise it is not complete. When only a part of the white light enters a substance, how can we expect that the whole of the white light should be reflected?—it would not be in accordance with the laws of the conservation of energy.

We may imagine that the intensity of the light employed has something to do with the above result. When I reflected an electric arc light from the polished surface of the Jerseyite and observed the same with a transparent replica of a diffraction grating held before the eyes, I saw the two carbon points and the nearest ray to them was blue, then green, yellow, orange and red; but the indigo and violet rays were absent, showing that even the intense electric arc had no better effect than the white glow of the Welsbach gas burner. When the reflected gray ray issuing from the same black surface is allowed to pass through a Nicol prism, we see that the ray is partially polarized; we have, therefore, elliptic polarization by this substance.

The material in question is but slightly magnetic. Although the substance is very brittle, I succeeded in preparing a thin section for the microscopic examination. Under the microscope I was rather surprised to discover two distinct forms of the matter; the one in well defined crystals and transparent, while the other was opaque and amorphous.

The etching process by diluted acid is now understood, for not only diluted nitric but also hydrochloric acid will penetrate it, whether polished or not, attacking the fine amorphous powder only and not touching nor affecting the crystal in mass. The form of the crystals is fairly well outlined; they seem to belong to the Orthorhombic system. The planes [110], [001], [010], [111] were recognized. The crystals form chain-like rows in such a manner that apparently each individual is separated from its neighbor by a black line of the amorphous non-transparent fine powder.

In polarized light these prismatic forms readily transmit the rays when inclined to the longer axis, and extinguish completely all light when brought parallel to the plane of polarization.

Mr. Arthur T. Collins volatilized fragments of the Jerseyite in the electric arc and projected the incandescent vapor on the collimator slit by means of lens in the hope of seeing whether the coronium line would appear in the field of vision. He reported to me that the result was negative. But, as is usually the case under these conditions, elements are detected which the chemical analyst cannot separate. The incontestable proof was given that barium, calcium and lithium were present. These elements, easily detected by the spectroscopist, could not be found by the analyst on account of the small quantity contained in the mass.

In this connection a singular phenomenon was observed not commonly met with:—When the arc between the carbon rods—the lower one supporting the fragment of the Jerseyite—began to glow, a thick volume of mineral vapor appeared; viewed now in the spectroscope the two sodium lines stood out sharply and each of them partially absorbed, i. e. the black Frauenhofer D-line coincided upon the yellow Na-line, a fact which Mr. Collins observed first and to which he directed my attention.

This singular double prenomenon seems to be due to the fact that the thick vapor sphere farthest away from the white hot carbons cools somewhat and partly absorbs the incandescent yellow Na-vapor. There is nothing new in this view, because it is essentially the Bunsen effect; but to find the reversion of the sodium line under these conditions seems worth recording.

The blowpipe test gave me the following indications: Silica, Titanic Acid, Iron, Copper and Tin.

THE CHEMICAL COMPOSITION.

The chemical analysis was performed by my esteemed friend Mr. W. J. Williams, a work which required considerable time and circumspection and to whom my thanks are due.

His results here follows:—

Silica,	SiO_2	42.80	per cent.
Titanic acid,	TiO_2	1.90	"
Tin oxide,	SnO_2	0.49	"
Bismuth oxide,	Bi_2O_3	0.22	"
Copper oxide,	CuO	0.26	"
Nickel oxide,	NiO	2.00	"
Iron	Fe	44.36	"
Aluminum oxide,	Al_2O_3	4.18	"
Calcium oxide,	CaO	Trace(doubtful)	
Potassium oxide,	K_2O	0.92	per cent.
Sodium oxide,	Na_2O	0.80	" (by difference)
Carbon,	C	1.84	per cent.
Sulphur,	S	0.34	"
Phosphorus,	P	0.12	"
		100.23	"
Deduct O=P+S		.23	"
		100.00	"

We see that in the Bausch analysis the essential elements had been recognized by the blowpipe tests.

The carbon is probably contained in the black amorphous powder surrounding the crystalline forms, which make up the principal part of this meteoric stone.

THE PRODUCTION OF ASBESTOS IN 1906.

Commercial asbestos includes two distinct types of fibrous minerals. The term asbestos was originally applied to actinolite or tremolite, but the more important asbestiform mineral is the fibrous variety of serpentine known as chrysotile. This variety is always associated with serpentine which is derived from the alteration of eruptive rocks. It has been reported as occurring in commercial quantities in Massachusetts, Vermont, North Carolina, Wyoming, Arizona, Washington, Oregon, and California.

The eastern townships of the province of Quebec furnish the greater part (85 per cent.) of the world's production of asbestos. In 1906 Canada exported 59,864 tons of asbestos, valued at $1,629,257, most of which came to the United States. Improved methods of mining are being introduced in Canada and the output there is increasing.

Both forms of asbestos are applied to many uses, depending in part upon the fibrous character of the material, but also upon its non-conductivity of

heat and electricity. The best grade of chrysotile fibre is spun into thread, yarn, and rope, and woven into cloth. The yarn is largely used for packings and the cloth for theatre curtains, while fabrics containing asbestos woven with other fibers are made into various household articles in which heat insulation rather than fire-proof character is required.

Asbestos is extensively used for plastering and for making lumber that is employed in buildings where insulation against fire and electricity are desired. Its use in fire-proof structures, and especially to envelop electrical conductors, is constantly increasing.

The production of asbestos in the United States in 1906 was 1695 tons, valued at $28,565, as against 3109 tons, valued at $42,975, in 1905. The imports in 1906 were valued at $1,076,170.

The output of all existing asbestos mines is insufficient to supply the demand for this product, and the leading manufacturing firms interested in the industry are diligently searching for new deposits.

An advance chapter from "Mineral Resources of the United States, Calendar Year 1906," on the production of asbestos in 1906, by J. S. Diller, is now ready for free distribution.

PRODUCTION OF MONAZITE AND ZIRCON IN 1906.

Monazite is of commercial interest as a source of the rare metal thorium, which is used in the manufacture of Welsbach and other incandescent mantles for gas lights. Deposits of this mineral have been found in North Carolina, South Carolina and Georgia, and in several States of the Far West. It is mined in North and South Carolina, the production in 1906 having been 847,275 pounds, valued at $152,560, as against 1,352,418 pounds, valued at $163,908 in 1905, the figures for both years including a small quantity of zircon.

The area in which minable deposits of monazite have been found is growing yearly, especially southwestward, in which direction it now reaches to the Georgia line.

Zircon has been obtained in quantity as a by-product from monazite concentrates. An experimental concentrating plant of the United States Geological Survey at Chapel Hill, N. C., is now making tests as to the best method of separating zircon and other products of commercial value from monazite concentrates. The output of zircon in 1906 all came from Henderson County, N. C.

An advance chapter of "Mineral Resources of the United States, Calenda: Year 1906," by D. B. Sterrett, on the production of monazite and zircon during that year, is now ready for distribution.

THE British consul at Goa reports that six concerns have commenced mining operations on the manganese deposits of Portuguese India.

Mining and Metallurgical Section.

(Stated Meeting held Thursday, October 3, 1907.)

Deflocculated Graphite.

By E. G. Acheson,
Member of the Institute.

In the year 1901 I was engaged in a series of experiments having as their object the production of crucibles from artificial graphite. In this work I was led into a study of clays. What I learned may be briefly stated as follows:

1st.—The American manufacturers of graphite crucibles imported from Germany the clay used by them as a binder of the graphite entering into the crucibles.

2nd.—The German clays are much more plastic and have a greater tensile strength than American clays of very similar chemical composition.

3rd.—Residual clays—those found at or near the point at which the parent feldspathic rock was decomposed—are not in any sense as plastic or strong as the same clays are when found as sedimentary clays at a distance from their place of origin.

4th.—Chemical analysis failed to account for those decided differences.

I reasoned that the greater plasticity and tensile strength were developed during the period of transportation from the place of their formation to their final bed, and I thought it might be due to the presence of extracts from vegetation, the washings from the forests being in the waters which carried them.

I made several experiments on clay with extracts of plants, tannin being one of them, and I found a moderately plastic, weak clay, when treated with a dilute solution of gallotannic acid or extract of straw, was increased in plasticity, made stronger,—in some cases as much as three hundred per cent.,—required but sixty per

cent. as much water to produce a given degree of fluidity, was caused to remain suspended in water and made so fine that it would pass through a filter paper. Being acquainted with the record of how the Egyptians had the Children of Israel use straw in the making of bricks, and how they substituted stubble for straw, and believing it was not used for any benefits derivable from the fibres but for the extract, I called the clay so treated "Egyptianized Clay."

Having in 1906 discovered a process of producing a fine, pure, unctuous graphite, I undertook to work out the details of its application as a lubricant. In the dry form, or mixed with grease, it was easy to handle, but I wished it to enter the entire field of lubrication as occupied by oil. In my first efforts to suspend it in oil, I met the same troubles encountered by my predecessors in this line of work,—it would quickly settle out of the oil. It obeyed the same laws covering the natural product.

So things stood until the latter part of 1906 when the thought occurred to me that tannin might have the same effect on graphite that it did on clay. I tried it with satisfactory results, the effect being obtainable with the natural graphites as found in the Ticonderoga and Ceylon varieties, and with the artificial product as found in Acheson-Graphite. It was more easily and cheaply produced when the soft, unctuous variety of my graphite was used, this kind being composed of pseudomorphs of carbide crystals, which had been decomposed in the electric furnace, the resultant graphite being very loose, porous and readily disintegrated and deflocculated. The effect was produced by treating the graphite in the disintegrated form with a water solution of tannin, the amount of tannin being from three to six per cent. by weight of the graphite treated. The results are much more pronounced when the mass of graphite, water, and tannin has been pugged or masticated for a considerable time, I having to advantage carried on this process continuously, without interruption, for a period of one month. I have also found that while the effect may be produced in a very satisfactory way with distilled water, the waters as found in rivers, deep wells, etc., are improved by the addition of a trace of ammonia. The presence of carbon dioxide in the water will prevent deflocculation.

The accompanying Figures 1 and 2 show the effect of tannin in suspending graphite. Figure 1 is that of two test tubes, one

containing water, a drop of ammonia and disintegrated Acheson-Graphite, the other tube containing a similar amount of water, ammonia and graphite, with the addition of a little gallotannic acid. The photograph was taken immediately after the tubes were thoroughly shaken. Figure 2 shows the same tubes and contents, four minutes having elapsed after being shaken, they not having been disturbed during that interval. These tubes furnish a very clear demonstration of the quick settling of graphite in plain water and the remarkable effect of the presence of tannin.

All of the graphite put into the tube with the tannin did not remain suspended. In fact, in this case, as illustrated, very

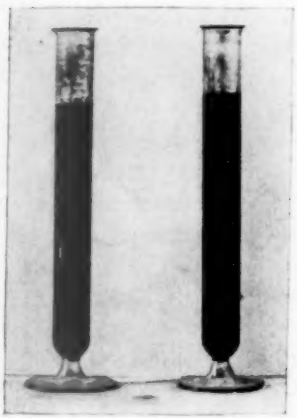


Fig. 1

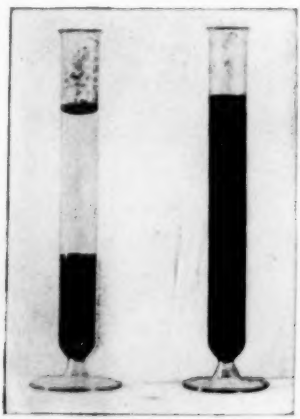


Fig. 2

nearly all of it had settled, only sufficient remaining in the water to give it its blackness. To cause a complete suspension of all the graphite necessitates prolonged mastication in the form of a paste with the water and tannin, and I find that after this mastication has been carried out that the effect is very much improved by diluting the mass with considerable water, and allowing it to remain some weeks with occasional stirring.

After the prolonged masticating and additional time of exposure of the graphite to the water and tannin, an intensely black liquid is obtained consisting of water, a small amount of tannin and graphite; the latter may be present in varying amounts. In this condition I call the graphite "deflocculated," a state of sub-

division much finer than possible of attainment by mechanical means, one that may perhaps be correctly spoken of as molecular. It is in that condition called "colloidal." This term, however, does not appeal to me, being only the name of a condition or state. The term "deflocculated" is much more readily understood, and, to an extent, it carries with it its own definition. I have found this liquid would pass throught the finest of filter papers, and the contained graphite would remain in suspension for weeks and months,—apparently for all time. One per cent. of graphite content makes the liquid so thick that it runs through the filter paper slowly; reduced to 0.2 of one per cent., it goes through quickly.

Fig. 3

Fig. 4

Figures 3 and 4 illustrate an experiment with water containing 0.2 of one per cent. graphite. Figure 3 shows a glass funnel containing a fine filter-paper resting in a test tube. In the tube below the funnel is a black liquid, which has passed through the filter paper. This black liquid is water containing 0.2 of one per cent. deflocculated Acheson-Graphite. The fact of its having passed through the filter paper leaves no doubt in our minds of the impossibility of separating the water and graphite while in this condition by ordinary filtration. I have found that the addi-

tion of a very minute amount of hdyrochloric acid causes the contained graphite to flocculate, i. e. group its molecules into masses so that it will no longer pass through the paper. Figure 4 shows, as in the former case, the funnel, filter paper and test tube; but now in the lower part of the tube, below the filter, we find a clear liquid, this being the water in which the deflocculated graphite was formerly suspended, the graphite now being caught entirely in the filter paper above. It will be noticed that the filter paper in Figure 3 is black on the outside, this having been produced by the deflocculated graphite passing through the paper, whereas the filter paper, as shown in Figure 4, remains white on the outside, the graphite not having passed through its body.

This effect is obtainable with non-metallic amorphous bodies generally, having been secured with silica, alumina, lamp-black, clay, graphite and siloxicon. An interesting line of thought may be entered into as to the part this effect plays in nature's economy. It is by this means Nature prepares the Potter's clay.

This graphite, even after flocculation, is so fine in its particles that when dried *en masse* it forms a hard article. It is self-bonding, like a sun-dried clod of clay.

I have successfully used deflocculated graphite in water instead of oil in sight-drop feed oilers and with chain feed oilers. I have a shaft in my laboratory measuring 2 5-16″ in diameter, revolving at 3000 revolutions per minute in a bearing 10 inches long that had no oil on it for a month, deflocculated graphite and water being the only lubricants used, the feed being by chain, and it ran perfectly. On the same shaft is a similar bearing lubricated with oil, and this ran much the warmer of the two.

A few days after this test was started a pessimistic friend remarked that just plain simple water would give the same results, that the presence of graphite was unnecessary. We are influenced by the opinions of others even when we know or think they are wrong. I emptied the oil out of the second bearing on the shaft and substituted plain water. The results during the first twelve hours seemed to support the contention of the friend. The next day after the machine had stood motionless over night, things did not look so well for the water; it was a lame "second" on account of rust, and was hurriedly removed. I think I shall not recommend clear water as a permanent lubricant.

Deflocculated graphite in water possesses the remarkable power of preventing rust or corrosion of iron or steel. This character-

istic will unquestionably make it of great value for some uses, and while, as yet, little has been done to explore the field, some work has already been accomplished in using it as a cutting compound in screw cutting, and I have been advised by one large manufacturer that the results obtained showed it to be equal or superior to lard oil when the water was carrying as little as one-half of one per cent. of its weight in graphite. It will readily be understood that while preventing rusting, the high specific heat of the water renders it of great importance, permitting of a high speed of the machinery, and consequently increased output. Another probable application of deflocculated graphite in water will be as a lubricant for condensing engine cylinders.

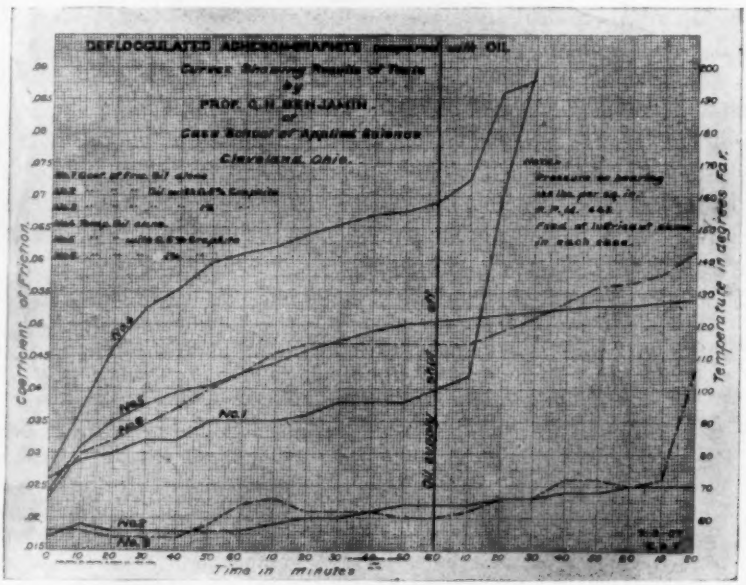
While, as I have stated, deflocculated graphite in water is an excellent lubricant for light work, it has the disadvantage of losing its water by evaporation, and I realized that to utilize the possible advantages of deflocculated graphite, it would be necessary to replace the water with oil; therefore, I set before me the task of accomplishing that result. When it is remembered that a removal of the water by evaporation previous to its replacement by oil would cause the contained graphite to assume the condition of a hard, flocculated, self-bonded mass, it will be seen that the problem was not simply one of the evaporation of the water and suspending the resultant dry graphite in oil. A very great deal of difficulty and many discouraging conditions were met with in my attempt to cross this apparently bottomless chasm, and I am pleased to say that I eventually succeeded, and I have been successful in suspending the deflocculated graphite in oil in a dehydrated condition. The graphite will remain suspended in the manner that it formerly did in the water, and we now have in this article a truly new lubricating body.

A new material having been created, as this would evidently seem to be, a new name is necessary, and I have added the initial letters of Deflocculated Acheson-Graphite, D-A-G, to "Oil" or "Aqua," when the deflocculated graphite is carried in oil or water as the case might be, and have "Oildag" and "Aquadag" respectively.

Prof. C. H. Benjamin, formerly of the Case School of Applied Science, Cleveland, O., and now Dean of the Engineering School of Purdue University, is engaged in making extensive tests to determine the value of deflocculated graphite as a lubricant, and,

while these tests are not as yet completed, he has proved that 0.5% by weight of this graphite in oil greatly reduces the co-efficient of friction and materially extends the life of the oil in which it is suspended as a lubricant. Figure 5 shows some of the results obtained in his tests with spindle oil, and by a study of them we find that comparing the initial co-efficient of friction of plain oil and oil containing one-half of one per cent. of graphite, the co-efficient of friction of the oil containing the graphite was

International Acheson-Graphite Co., Niagara Falls, N. Y., U.S.A.



Initial Friction Oil and 0 5 per cent. Graphite . . .	65 per cent. of oil alone
After 120 m. Friction " " " . .	55 " "
Friction of Oil increased	54 per cent.
Friction of Oil and Graphite increased	30 "
After lub. was shut off friction of oil increased	125 per cent. in 30 min.
After lub. was shut off friction of oil and graphite . .	14 " " 80 "

Spindle oil was used in all tests

but sixty-five per cent. of the plain oil, while after one hundred and twenty minutes, it was but fifty-five per cent., the friction of the oil having increased fifty-four per cent., while with the contained graphite it increased but thirty per cent. After shutting off the supply of the lubricant on the bearing, the co-efficient of

friction of the oil alone increased in thirty minutes 125%, whereas the co-efficient of the oil with one-half of one per cent. of graphite increased in eighty minutes but 14%. In fact, at the end of the entire run of 200 minutes its co-efficient of friction was less than the initial friction of the plain oil.

I have myself been making tests of the efficiency of my product as a lubricant for automobile gasoline engine cylinders, with the result that I very materially reduced the consumption of oil. A Packard No. 30 automobile that I am operating ran over 4,000 miles without the necessity of cleaning the spark plug, and what is still more remarkable, without the necessity of grinding the valves. The usual practice being to clean the plugs and grind the valves at least in 1500 miles. It would perhaps be too early to state positively that the use of Oildag in the gas engine would eliminate the pitting of the valve seats, but the results that I have so far obtained would rather indicate such a possibility. The surfaces produced on the valve seats are remarkable, being much finer than is possible of attainment by any mechanical finishing, the graphite being incorporated in the body of the metal.

PRODUCTION OF MICA IN 1906.

Of the minerals composing the group called mica practically but two—muscovite or potash mica and phlogopite or magnesia mica—are industrially important, and only one of these, the muscovite, is found in deposits of commercial value in the United States. This muscovite is widely disseminated in small plates and crystals, of no value, in crystalline igneous and metamorphic rocks, as well as in the sediments derived from them, but the commercially valuable deposits are confined to pegmatite—a rock closely allied to granite in composition, composed of feldspar and quartz, with more or less mica and other accessory minerals, but unlike granite in that its minerals are crystallized out in large masses. Among the coarser products of this crystallization is the mica, blocks of which more than a yard in diameter have been found

The properties which give mica its value to the world of industry are its perfect cleavage, the toughness, flexibility, and elasticity of its cleavage sheets, and its transparency and non-conductivity of electricity. The three principal uses of the material are for electrical insulation, glazing, and decoration. The first-named use probably leads in present importance, but the other two uses date back to ancient times, mica antedating glass and also being early used to secure decorative effects. As an insulating material it occupies a place that cannot be filled by any other substance. Recently the

utilization of scrap and waste mica in the manufacture of lubricants for car axles has become a somewhat important industry in the West.

The increasing use of the material has largely modified the demand made upon the mining industry, for not only can sheet mica of small size now be utilized, but even more important is the extensive use that is now made of composite mica, molded mica, "micanite," and other varieties of built-up sheets. Scrap mica is also utilized in the manufacture of a superior quality of boiler lagging, and ground mica is used in somewhat increased quantities in mica bronzes and paints and as an absorbent for explosives. The finest ground mica, or mica flour, finds a considerable market with manufacturers of high-grade wall papers, the luster obtained by the use of muscovite dust having the advantage of both permanency and brilliancy.

In an advance chapter from the "Mineral Resources of the United States, Calendar Year 1906," Douglas B. Sterrett, of the United States Geological Survey, reports the production of sheet mica in the United States for 1906 as 1,423,100 pounds, valued at $252,248, and of scrap mica as 1489 short tons, valued at $22,742. These figures show an increase over those for 1905 of 498,225 pounds in quantity and $91,516 in value for sheet mica, and of 363 tons in quantity and $4,886 in value for scrap mica. The eight States which shared this production are, in order of value of output, North Carolina, Colorado, New Hampshire, Virginia, Idaho, South Dakota, New Mexico, and Connecticut.

The imports of mica into the United States in 1906 were the largest ever recorded, the value being considerably more than twice as great as in 1902 and 1905, the years that formerly held the record. According to Mr. Sterrett, the total quantity imported and entered for consumption in 1906 amounted to 3,066,738 pounds, valued at $1,042,608.

The total production and consumption of sheet mica in the United States in 1906 was 4,489,838 pounds, as against 2,519,445 pounds in 1905, an increase of about 78 per cent. A comparison of the import figures with those of the home production shows that there is a wide field for the extension of the industry in the United States, and indeed the industry is expanding rapidly to meet the demand. Deposits carrying mica in commercial size are found in many parts of the United States from the Atlantic coast to the Pacific, and new developments are reported each year. Alabama and Georgia will probably appear in the list of producing States in 1907, and other States will doubtless show large gains in production.

Mr. Sterrett's paper, which is ready for distribution and may be obtained by applying to the Director of the United States Geological Survey, at Washington, D. C., contains much interesting and valuable information concerning the material and the methods of mining and manufacturing it, and includes a list of publications dealing with the subject.

QUARTZ (FLINT) AND FELDSPAR PRODUCTION IN 1906.

Quartz, the most abundant of all the minerals, occurs in so great variety of form and is utilized commercially in so many different ways that the statistics of its annual production prepared by the United States Geological Survey are comprised under several heads. Certain transparent, colored varieties of the mineral, such as rose and smoky quartz and amethystine quartz, have a gem value and are discussed in connection with precious stones; sand used for building, molding, and in pottery manufacture is separately treated, as are also sandstone and quartzite used for building purposes, although all of these materials consist of nearly pure quartz. The massive crystalline quartz, often called vein quartz, with flint and with quartzite, used for other than building purposes, and the associated and widely distributed feldspar deposits are grouped together and are discussed in an advance chapter from the report on "Mineral Resources of the United States, Calendar Year 1906." This chapter, prepared by Edson S. Bastin, is now ready for distribution.

The varieties of quartz dealt with in Mr. Bastian's report have a wide range of uses. Massive crystalline (vein) quartz is produced in Connecticut, New York, Maryland, and Virginia. That from the last-named State is used in the manufacture of metallic silicon and ferro-silicon by electrolytic processes, these materials being largely employed in steel manufacture to increase the toughness of the product. A large proportion of the quartz from New York, Connecticut and Maryland is ground and utilized in the manufacture of a wood filler. Massive quartz in blocks is used in the chemical industry as a filler for acid towers and to some extent as a flux for smelting copper; ground, it is used extensively in the manufacture of sandpaper, sand belts, scouring soaps, and polishes as a scouring agent in sand-blast apparatus, and in filters, and some of the finest grades are used by the dentists as cleaners. So far as known very little domestic flint has ever been commercially utilized, although its quality appears to be equal to that of the imported flint, which is brought in cheaply as ballast from France, Greenland, Norway, and England, and much of which is burned in kilns and ground for use in the pottery trade. Vein quartz is also used by pottery manufacturers.

According to Mr. Bastian, the production of quartz in the United States in 1906 amounted to 41,314 short tons of the crude material, valued at $37,632, and 25,383 short tons of ground quartz, valued at $205,380; a total of 66,697 short tons, valued at $243,012. These figures do not represent the entire amount of quartz and flint consumed for the year, for flint is imported to the value of $272,607.

The commercial fieldspar produced in the United States occur usually as constituents of pegmatites, and to meet the needs of the pottery manufacturers, by whom they are chiefly used, they must contain from 15 to 20 per cent. of free quartz. The material is used principally as a constituent of both body and glaze in true porcelain, white ware, and vitrified sanitary ware, and as a constituent of the slip (underglaze) and glaze in the so-called "porcelain" sanitary wares and enameled brick. At present it is quarried in Maine, New York, Connecticut, Pennsylvania, Maryland, Texas, and

Minnesota, and the total production in 1906 amounted to 39,976 short tons of crude feldspar, valued at $132,643, and 32,680 short tons of ground feldspar valued at $268,888; a total production of 72,656 short tons, valued at $401,531. The use of the mineral is increasing and the domestic supply is supplemented by large importations from Ontario, Canada.

Book Notices.

Elements of General Chemistry with experiments, by John H. Long. 4th edition, revised and enlarged. 443 pages illustrations, 12-mo. Philadelphia, B. Blakiston's Son & Co., 1906. Price, cloth, $1.50.

This work first appeared in the year 1898. The present edition is brought up to date and includes a chapter on the theories of solution and the conditions of chemical equilibrium. There are one hundred and seventy-five experiments in all fields of chemistry, interspersed with much information of value to beginners in the study of the science. R.

A Text-Book of Elementary Analytical Chemistry, qualitative and volumetric, by John K. Long. Third edition, revised and enlarged. 299 pages, illustrations, 12-mo. Philadelphia, P. Blakiston's Son & Co., 1906. Price, cloth, $1.25.

The present volume is intended for students who have gone through the work on general chemistry by Prof. Long. The author has arranged his course to meet the special needs of the students in the chemical laboratories of the Northwestern University Medical School, at Chicago. The book is uniform in appearance and size with the one previously noted.

R.

Wellcome's Photographic Exposure Record and Diary. United States Edition. 1907. 260 pages, illustrations, plates, 24-mo. New York, Burroughs, Wellcome & Co. Price, 50 cents.

This annual contains considerable information which will be useful to the amateur photographer. It deals with developers and development, restrainers, fixing and hardening, and other matters of importance in the photographic laboratory. The leading feature of the book is the exposure calculator which is attached to the back cover. It is a movable disc, by means of which the approximate exposure can be ascertained for any subject or plate. A dozen pages are devoted to light values of the different months, and a table gives the speed of about two hundred makes of plates and films. In addition to the blank pages for the diary there are also a number of pages carefully ruled for the purpose of recording negative exposures and positive exposures. The work is issued in pocket-book form and is adorned with several half-tone reproductions of photographs.

R.

Elementary Practical Chemistry. Part II. Analytical Chemistry. Qualitative and Quantitative. By Frank Clowes and J. Bernard Coleman. Fifth edition. 237 pages, illustrations, 12-mo. London, J. & A. Churchill,

1907. On sale in Philadelphia at P. Blackiston's Son & Co. Price, cloth, $1.00.

In the revision of this work additions have been made to the volumetric and gravimetric portions, and a new section on inorganic preparations has been added. R.

Principles of Qualitative Analysis from the Standpoint of the Theory of Electrolytic Dissociation and the Law of Mass Action. By William Böttger, translated with the author's sanction and revised with his cöoperation by William Gabb Smeaton. 300 pages, illustrations, 8-vo. Philadelphia, P. Blakiston's Son & Co., 1906. Price, cloth, $2.00.

This text-book introduces modern conceptions into the teaching of qualitative analysis. Part I is devoted to testing a solution for metals; Part II, testing a solution for anions; Part III, the complete analysis of a given unknown; Part IV, the rare elements. There are analytical tables, including tests for cathions and anions and preliminary tests and methods of bringing solids into solutions. R.

Construction des Induits a Courant Continu L'Arbre et ses tourillons par E. J. Brunswick et M. Aliamet. 172 pages, illustrations, 12-mo. Paris, Gauthier-Villars, n. d. Price, paper, 2 francs, 50 c.; cloth, 3 francs.

Commutatrices et Transformateurs Electriques Tourants par Jean Paraf. 194 pages, illustrations, 12-mo. Paris, Gauthier-Villars, n. d. Price, paper, 2 francs, 50 c.; cloth, 3 francs.

These recent additions to the Encyclopédie Scientifique des Aide-Mémoire will appeal especially to the electrical engineer. Any one having a knowledge of French will find this series extremely useful.

R.

L'Annee Technique, 1906, par A. Da Cunha. Préface de Alfred Picard. 237 pages, illustrations, 4to. Paris, Gauthier-Villars, 1906. Price, paper, 3 francs, 50 c.

The leading article in this technical review of the past year relates to inventions and devices for the protection of the lives and limbs of workmen. There is also considerable space given over to the subject of heating and the distribution of water in houses. Thirty pages are devoted to a review of the work done in civil engineering and these are followed by a report on recent advances in locomotion, including automobiles. The volume is made up with the same care as heretofore.

Missouri Bureau of Geology and Mines. The quarrying industry of Missouri. By E. R. Buckley and H. A. Buehler. Forming Volume II, Second Series of the reports. 371 pages, illustrations, plates, maps, 4to. Jefferson City, State Printers, 1904.

This is a comprehensive report on the quarries of the State and their products, with a brief geological history. It deals with the uses and properties of building stones and the composition of rocks and rock structures. The chapter devoted to laboratory tests contains much interesting information on the strength of stones and the effect of thawing and freezing. R.

Thermodynamik technischer Gasreaktionen. Sieben Vorlesungen von Dr. F. Haber a. o. Professor an der Technischen Hochschule Karlsruhe i. B. 296 pages, illustrations, 8-vo. München, R. Oldenburg, 1905. Price, cloth, 10 marks.

These lectures were delivered before advanced students and colleagues of the author. The work treats of the practical and not the theoretical side of the question; it is intended to serve as a work of instruction and as an aid in the experimental investigation in the field of technical gas reactions and forms a supplement to the literature on the subject in the various technical periodicals. It is not a complete reference book but simply a guide, dealing with the salient points.

The work is carefully done and there are many references to the labor of others in this field. R.

Hypochlorite und Elektrische Bleiche. Technisch-Konstruktiver Teil von Viktor Engelhardt. 275 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1903. Price, paper, 12 marks.

Die Elekrolytische Raffination des Kupfers von Titus Ulke, Ins Deutsche übertragen von Viktor Engelhardt. 152 pages, illustrations, plates, 8-vo. Halle a. S., Wilhelm Knapp, 1904. Price, paper, 8 marks.

Elektrolytisches Verfahren zur Herstellung parabolischer Spiegel von Sherard Cowper-Coles, Ins Deutsche übertragen von Dr. Emil Abel. 17 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1904. Price, paper, 1 mark.

Künstlicher Graphit von Francis A. J. Fitzgerald, Ins Deutsche übertragen von Dr. Max Huth. 60 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1904. Price, paper, 3 marks.

Die Elektrolyse geschmolzener Salze. Erster Teil; Verbindungen und Elemente von Richard Lorenz. 217 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1905. Price, paper, 8 marks.

Die Elektrolyse geschmolzener Salze. Zweiter Teil: Das Gesetz von Faraday; die Uberführung und Wanderung der Ionen; das Leitvermögen von Richard Lorenz. 257 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1905. Price, paper, 8 marks.

Die Elektrolyse geschmolzener Salze. Dritter Teil: Elektromotorische Kräfte von Richard Lorenz. 322 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1906. Price, paper, 10 marks.

Elektrolytische Alkalichloridzerlegung mit flüssigen Metallkathoden von Dr. R. Lucion. 206 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1906. Price, paper, 9 marks.

Die elektrochemischen Deutschen Reichspatente. Auszüng aus den Patentschriften gesammelt, geordent und mit Hinweisen versehen von Dr. P. Frechland und Dr. P. Rehlander. 230 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1906. Price, paper, 10 marks.

Deutskhes Patentrecht für chemiker von Dr. Julius Ephraim. 608 pages, 8-vo. Halle a. S., Wilhelm Knapp, 1907. Price, paper, 18 marks..

Elektrometallurgie des Eisens von Dr. Bernhard Neumann. 176 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1907. Price, paper 7 marks.

Uber die elektrolytische Gewinnung von Brom und Jod von Dr. Ing. Max Schlötter. 50 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1907. Price, paper, 2.40 marks.

The above are among the later issues of the series "Monographien über Angewandte Elektrochemie." The student of electro-chemistry will be most interested in the three volumes of Dr. Lorenz on the electrolysis of salts; the chemist with an inventive turn of mind will find much in Dr. Ephraim's work on the German patent laws and in the work on the electrochemical patents of Germany. Two volumes of the series are translations from the English, and it is hoped that some of the other issues may be translated into English for the benefit of those who are unable to make use of the works in the original. R.

Sections.

(Abstract of Proceedings.)

MINING AND METALLURGICAL SECTION:—A stated meeting of the Section was held Thursday, October 3d, at 8 P.M.

In the absence of the President, Professor A. E. Outerbridge was called to the chair. Present, twenty-seven members.

The Chairman introduced Mr. E. G. Acheson, of Niagara Falls, N. Y., who presented the paper of the evening on Deflocculated Graphite.

The speaker illustrated his remarks by the exhibition of specimens which showed the peculiar properties of the new product.

The paper was discussed by Messrs. Carl Hering, C. J. Reed, H. F. Colvin, the Chairman, the author, and others. On Mr. Colvin's motion, duly seconded, a vote of thanks was passed to the speaker of the evening, and his paper was referred for publication. Adjourned.

W. J. WILLIAMS, *Sec'y pro tem.*

ELECTRICAL SECTION:—Stated meeting held Thursday, October 10, 8 P.M. Mr. Thomas Spencer in the chair. Present, forty-five members.

The paper of the evening was presented by Dr. Joseph W. Richards, of Lehigh University. Subject: The Electro-Thermic Production of Iron and Steel. The speaker introduced his remarks by reference to the rapidly growing importance of the subject, and called special attention to two recent official reports made by a special technical commission appointed to investigate the subject, by the Canadian Government.

The speaker described the present state of the art, with special consideration of the electric production of steel, the reduction of iron direct from the ore, and the production of ferro-alloys of the rare metals, tungsten, molybdenum, vanadium, etc.

The construction and mode of operation of the several types of electric furnaces were described and illustrated by means of lantern views.

In his comments on the various aspects of the industry, Dr. Richards declared his belief that the electro-thermic methods had so far progressed as to make it practically sure that the crucible steel process was doomed to early extinction; also, that the commercially economical production of iron direct from the ore, was now assured in a number of localities, such as Norway, Canada, and elsewhere, where cheap electric power could be depended on; and that a highly important branch of the art—the production of ferro-alloys, had already attained the dignity of an established industry.

The paper was discussed by Messrs. Outerbridge, Garrison, Conrad, Wahl, Colvin, Goldsmith, Loss, Hering, the chairman and the speaker.

At the close of the discussion, on motion of Mr. H. V. Loss, duly seconded, Dr. Richards was accorded a vote of thanks for his interesting and instructive remarks, and his paper was referred to the Committee on Publication. Adjourned.

RICHARD L. BINDER, *Secretary.*

SECTION OF PHYSICS AND CHEMISTRY.—Stated meeting held Thursday, October 17, 8 P.M. Dr. Rob't H. Bradbury in the chair. Present, forty-two members.

After the transaction of the formal business of the meeting, the President introduced the speakers of the evening.

Dr. Edward Goldsmith read a paper entitled, "The Jerseyite," describing a meteoric stone which recently had been observed to fall in the neighborhood of Gloucester, N. J. The paper will be found in the *Journal.* It was discussed by Dr. Wahl and the author.

Mr. Lowndes Taylor, of West Chester, Pa., a member of the Section, exhibited and described an Original Form of "Platting Range Finder."

Dr. Henry Emerson Wetherill exhibited and described a number of improved instruments for navigation, which, on motion, were referred to the Committee on Science and the Arts for investigation and report. Adjourned.

EDWARD A. PARTRIDGE, *Secretary.*

Committee on Science and the Arts.

(Abstract of proceedings of the stated meeting held Wednesday, October 2d, 1907.)

DR. WM. O. GRIGGS in the chair.

The undermentioned reports were adopted:

(No. 2392.) *Improvements in Diffraction Color Photographs.* Herbert E. Ives, Weehawken, N. J.

ABSTRACT:—The subject of this investigation is an application of the well-known three-color method of reproducing color and combinations of colors by photography, and is, essentially, an improvement on a process

invented by Prof. R. W. Wood, now of Johns-Hopkins University, Baltimore, Md.

The invention is covered by U. S. Letters Patent No. 817,569, filed October 19, 1905, and granted April 10, 1906. Mr. Ives has fully described his inventions in a paper read before the Institute, which may be found in the *Journal* for June, 1906, page 439, *et seq.*

In diffraction color photographs the colors are produced by three superposed or mixed diffraction grating images, each grating providing, by a suitable disposition of viewing apparatus, one of the three primary colors.

The diffraction color photographs made by Prof. Wood had the diffraction-grating images superposed on the same plate, or on two or three plates in register. Prof. Wood in a paper read by him before the British Association, and published in Nature (Vol. lxx, page 614, 1904), called attention to the fact that in practice the superposing of the lines of the diffraction grating tended to produce additional disturbing effects, or false colors, by the rearrangement of the superposed lines giving spectra that were out of harmony with those of the normal diffraction gratings.

Even a modification of the Joly process, that was tried by Prof. Wood, did not give uniformly satisfactory results, largely, perhaps because of the difficulty of securing perfectly satisfactory Joly pigment screens, and also because of the occasional occurrence of secondary diffraction grating lines with the lines of the Joly screen.

To overcome these objections Mr. Ives makes use of continuous glass gratings, such as are usually employed in making diffraction gratings, but prints through a screen with alternate opaque and transparent spaces being twice the width of the transparent ones.

As a fourth modification of the original method, Mr. Ives has been able to practically apply a suggestion made by Mr. Thorp, of Manchester, England, in 1900, and produce all of the necessary color by the use of a single diffraction grating rotated to different angles. * * * * The resulting picture constitutes a refraction color photograph composed of juxtaposed lines or strips of diffraction lines, the lines of each strip being spaced differently from those of the other strips. When viewed in the special device designed by Mr. F. E. Ives, the pictures thus prepared are highly satisfactory and reproduce the original colors in a manner that approximates very well the results that have been obtained with the Chromoscope.

The report recommends, in conclusion, for the ingenuity and originality displayed in the invention, the award to Herbert E. Ives of the Edward Longstreth Medal of Merit. *(Sub-Committee:*—M. I. Wilbert, Chairman; A. W. Goodspeed, J. W. Ridpath.)

(No. 2404.) *Electric Furnace for the Production of Carbon Bi-Sulphide.* Edward R. Taylor, Penn Yan, N. Y.

This is reserved for publication in full. The report awards the Elliott Cresson Medal to the inventor. *(Sub-Committee:*—Jos. W. Richards, Chairman; Carl Hering, S. S. Sadtler.)

(No. 2408.) *Pressed Steel Pulleys.* Ferdinand Philips, Philadelphia, Pa.

This report is reserved for publication in full. The report awards the Elliott Cresson Medal to the inventor. *(Sub-Committee:*—Hugo Bilgram, Chairman; Kern Dodge, J. Y. McConnell.)

(No. 2409.) *Diffraction Color Photographs and Process of Making Same.* Prof. R. W. Wood, Johns-Hopkins University, Baltimore, Md.

ABSTRACT:—The invention of Prof. Wood is covered by U. S. Letters Patent No. 755,983, dated March 29.

This process depends on the production of color sensations by diffraction gratings of varying grating spaces placed between the eye of the observer and the source of light.

Prof. Wood described his invention in a paper entitled, "An application of the Diffraction Grating to Color Photography," published in the Philosophical Magazine for April, 1899. Further details of the process were subsequently published in Nature, in the Journal of the Society of Arts, London, and in other scientific journals. The process depends on the bending of the rays of light, by diffraction gratings of varying fineness. The diffraction gratings used for this purpose are of glass ruled with fine parallel lines—several thousand to the linear inch. When a fine point or line of light is viewed through such a plate or diffraction grating there will be seen spread to either side of the source of light or central image, a series of spectra beginning with red at the furthest or extreme end of the visible spectrum. By the use of a coarser or finer grating these spectra can be displayed nearer or farther from the central image at will and the several portions can thus be made to be superposed at one given point.

Prof. Wood's patent is for the finished photograph and for a method of producing multi-colored photographs by superposing monochrome records of multi-colored objects made through properly selected color screens and photographing them in accurate register through suitable diffraction gratings adapted to produce, at a given point, the color corresponding to that of the color screen.

The pictures themselves are produced by using positives, such as those made by Mr. Ives for his Chromoscope and printing, on a sheet of thin glass flowed with a solution of bichromated gelatine, successively the red, the green and the blue record positive through the corresponding diffraction grating.

The method followed by Prof. Wood is described at some length in the Journal of the Society of Arts, London, for February, 1900, page 287. The completed picture is described as "A photograph consisting of a surface having superposed diffraction rulings of different spacing, each spacing of diffraction ruling being adapted to produce a different color.

The patent granted to the inventor appears to cover the fundamental principles applied to the reproduction of color in photographs by the diffraction process and the practical results that he has shown appear to indicate that he has been able to secure satisfactory and highly interesting pictures.

In recognition of the thought and originality displayed by Prof. Wood in the production and in the subsequent development of diffraction color

photographs and the method of making them, the report recommends the award of the John Scott Legacy Premium and Medal to the inventor. *(Sub-Committee:*—Martin I. Wilbert, Chairman; A. W. Goodspeed, J. W. Ridpath.)

The following report passed first reading:

(No. 2411.) *Diffraction Chromoscope.* Frederic E. Ives, New York, N. Y.

PROTESTS against the following reports were received and considered, and the subjects were referred back to their respective Committees:

(No. 2400.) *Primary Battery.* Frank A. Decker, Philadelphia, Pa.

(No. 2401.) *Electrical Pyrometer (LeChatelier).* W. C. Heraeus.

NEW BUSINESS:—Report No. 2389—*Townsend's Thermometer Support,* adopted March 6th, 1907, was made the subject of a motion by Dr. Williams, duly seconded, directing a reconsideration of the Committee's action.

Adjourned.

LOUIS E. LEVY, *Sec'y pro tem.*

The Franklin Institute.

(Proceedings of the stated meeting held Wednesday, October 16th, 1907.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, PA., October 16, 1907.

DR. EDWARD GOLDSMITH in the chair.

Present, forty-two members and visitors.

Additions to membership since last report, four.

After the transaction of the usual formal business, the chairman introduced Prof. Oscar C. S. Carter, of the Central High School, who presented a communication entitled, "Camden's Water Supply is not Derived from the Delaware River by Infiltration."

The speaker illustrated his address with the aid of charts and lantern photographs.

The paper, giving the author's proofs of his thesis, appears in the *Journal* for November, 1907.

After a full discussion of the subject the thanks of the meeting were voted to the speaker of the evening. Adjourned.

WM. H. WAHL, *Secretary.*